THE
POPULAR SCIENCE
MONTHLY.

NOVEMBER, 1913

THE HISTORY OF DIETETICS

By JOHN BENJAMIN NICHOLS, M.D.

WASHINGTON, D.C.

THE manifold diversities in diet, the articles employed as food, the manner of preparing food, customs of eating, etc., among different peoples and at different times have been the outcome of fortuitous evolution, unguided and uninfluenced by definite physiologic principles. An account of the development of such dietary practises would present much of interest and would be included in a complete history of dietetics; but it is far too large a subject to be considered here, and the present paper will be limited to a brief presentation of the development of the various lines of knowledge constituting the scientific basis of dietetics, as it exists to-day.

Inquiring and speculative minds in all ages have endeavored to trace out the principles and laws governing diet. Prior to the modern scientific era, that is, during the entire ancient and middle ages, there was very little foundation of real knowledge on which a true science of dietetics could be based. Only the crudest objective characteristics of foodstuffs could be appreciated, such as the division of animal and vegetable, liquid and solid, etc. Notwithstanding the want of any adequate basis, from the time of Hippocrates a large proportion of medical literature was devoted to the subject of dietetics, and a multitude of treatises on food were presented characterized by chimerical speculation and fine-spun theorizing. Mythical properties and dangers were ascribed to different foodstuffs; rules were laid down in minute detail as to the use or prohibition of various foods in different morbid conditions which were without rational warrant; dietetic theories and systems were propounded which in the light of modern knowledge are seen to have been grotesque; and the authorities expounded their doctrines with an emphasis and dogmatism paralleled only by their real ignorance of the subject. Of all the mass of dietetic doctrine presented in the ancient

and medieval eras of medical thought, there was very little of abiding verity or value that contributed to our present rational knowledge of the subject. On the contrary, the professional mind was thoroughly indoctrinated with erroneous ideas which retarded the acceptance of correct conceptions and have not even yet been eradicated.

The science of dietetics is a composite subject, uniting a number of rather independent branches of knowledge, such as the chemistry of food, the processes of digestion, the physiology of metabolism, etc., the development of which may be separately considered. The beginnings of our scientific knowledge of these subjects may be traced back to the seventeenth century, soon after the discovery of the circulation of the blood by William Harvey (1578–1667), announced in 1628, opened the way to the development of scientific physiology. No great progress, however, was made for nearly two centuries, and the main foundations of our knowledge of these subjects were laid down in the second quarter of the nineteenth century.

The development of our knowledge of the physiology of digestion will be first considered.

A knowledge of the mechanism of glandular secretion in general is prerequisite to an understanding of the origin of the digestive fluids. No adequate conception of the structure and function of glands was possible prior to the discovery of the circulation and the use of the microscope. When these conditions were fulfilled the physiology of glandular secretion was quickly worked out. At first, for instance, it was not even known that, except for the liver and kidneys, the glands possessed ducts. The main steps in the evolution of our knowledge of glandular action were about as follows:

In 1643 the duct of the pancreas was first described by Georg Wirsung, a Bavarian (died 1643), although his pupil Maurice Hoffmann contested the honor of its discovery as his own. In 1654 Francis Glisson, an Englishman (1597–1677), published an important work on the liver, in which he touched upon the mechanism of the secretion of the bile. In 1656 Thomas Wharton, an Englishman (1610–1673), published an account of the duct of the submaxillary gland. In 1662 Lorenzo Bellini, of Florence (1643–1704), at the early age of 19 years, described certain portions of the uriniferous tubules of the kidney. In 1662 also Nicolas Stensen, or Steno, a Dane (1638–1686), described the ducts of the parotid and other glands. The names of these observers have ever since been attached to the structures which they discovered.

About this time Franciscus Sylvius, Stensen's instructor at Leyden, drew a general distinction between conglomerate glands, possessing secretory ducts, such as ordinary secreting glands, and conglobate glands, such as the lymphatic glands. Stensen, from his researches on the salivary and other glands, came close to an adequate conception of the process of glandular secretion; but as, like the other observers just

mentioned, he did not employ the microscope, he was unable to work out the full details of the subject. It remained for Marcello Malpighi (1628–1694), of Bologna, a pioneer microscopist and one of the first and greatest of histologists, in 1666 to lay down finally the essential features of the minute structure and mechanism of the main glandular organs as they are accepted at the present time.

The lacteals were discovered in 1622 (published 1627) by Gaspare Aselli (1581–1626), professor at Pavia, who recognized that they conveyed the chyle away from the intestine, but regarded them as emptying into the liver, then thought to be the organ in which the food materials were converted into blood. The discovery of the receptaculum chyli and the thoracic duct, and the connection of these with the lacteals on the one hand, and the venous system on the other, was made independently by Jean Pecquet (1622–1674), of Dieppe and Paris, and Jan van Horne (1621–1670), of Leyden, whose observations were published in 1651 and 1652, respectively.

In the ancient and middle ages, the stomach was looked upon as the principal organ of digestion. The process of digestion was by some (Hippocrates and others) regarded as a coction, or πέψις (cooking), a sort of maturation effected with the aid of heat; by others it was considered as akin to putrefaction; and by still others as a mechanical process. It came to be the general doctrine that the food material absorbed from the alimentary tract was first acted upon by the liver and endowed with "natural spirits"; in the heart, by the action on the blood of the inspired air, the natural spirits were converted into "vital spirits"; finally, in the brain the vital spirits were converted into "animal spirits," which were then conveyed by the nerves to all parts of the body.

The beginnings of our modern knowledge of digestion can be traced back to the observations of the Belgian savant Jean Baptiste van Helmont (1577–1644), whose work formed a landmark in the history of chemistry. He regarded the chemical activities of the body as a form of fermentation, analogous to the familiar alcoholic or vinous fermentation; he assigned ferment action as a cause of a wide range of vital processes, thus anticipating theories that at the present time are frequently advanced. In van Helmont's view the digestion of food was accomplished by fermentative action. He recognized only two stages of digestion in the alimentary tract, namely, in the stomach and in the duodenum; the action of the salivary glands and pancreas was not yet known. Gastric digestion he regarded as being effected by a ferment derived from the spleen, associated with an acid principle which was necessary to its action. When the chyme passed into the duodenum the acid ferment was neutralized, and the second stage of digestion was effected by the bile.

The next developments in the knowledge of digestion came from

Franciscus Sylvius (François de la Boe, or Dubois, 1614–1672), the professor of medicine at Leyden, who founded the iatro-chemical school and exerted a powerful influence as a teacher and expositor of the chemical philosophy of his time. Sylvius also attributed many of the vital processes to fermentative action; but he confused effervescence (such as occurs on adding acid to carbonate) with fermentation, and looked upon effervescence as the type of these processes. Sylvius had knowledge of two secretions, salivary and pancreatic, unknown to van Helmont.

The observations of Wharton and Stensen (published 1656 and 1662) had clarified the salivary secretion. Impressed with these discoveries, Sylvius attached an exaggerated importance to the digestive action of the saliva, and held that digestion in the stomach was accomplished much more by swallowed saliva than by any ferment of gastric origin. This view persisted for a long time.

The second stage of digestion, that taking place in the duodenum, according to Sylvius was effected by the conjoint action of the bile and the recently discovered pancreatic juice. Wirsung in 1643 had described the pancreatic duct; and in 1664 Regner de Graaf (1641–1673), of Holland, published the results of investigations on the pancreatic secretion carried out while he was a student at Leyden under Sylvius. De Graaf obtained pure pancreatic juice from dogs through quills inserted into the pancreatic duct. He fell into the error, however, of regarding it as acid; and he held, in accordance with Sylvius's theory of effervescence, that the effervescence supposed to be produced by the mixture of this acid juice with the salts of the bile was in some way associated with duodenal digestion.

In 1677, Johann Conrad Peyer (1653–1712), a Swiss, published a description of certain glandular structures discovered by him and since known as Peyer's patches. He decided that these were secretory (conglomerate) rather than lymphatic (conglobate) glands, and believed their secretion had digestive properties, active in the lower ileum at a point where the pancreatic juice must become exhausted.

In 1683, Johann Conrad Brunner (1653–1727), of Germany, published the results of experiments which he had made in exsecting the pancreas and ligating the pancreatic duct in dogs. As the dogs did not manifest any disturbance of digestion or nutrition, he argued that the importance attached by Sylvius and de Graaf to pancreatic digestion was unfounded. Brunner also showed that the pancreatic juice was not acid. In 1687 he described the duodenal glands, since known by his name, and attributed digestive properties to their secretion.

In consequence of the doubt brought by the discoveries of Peyer and Brunner, belief in pancreatic digestion waned, and for a long time the view prevailed that the stomach was the chief seat of digestion. In the latter part of the seventeenth century, two opposing theories as to the

mechanism of gastric digestion were held by the rival physical and chemical schools of that period. The chemical theory of digestion was that of van Helmont, Sylvius, and their followers. On the other hand, Alfonso Borelli (1608–1679), the founder of the iatro-physical school, held that gastric secretion was chiefly effected by powerful trituration of the ingested food by the muscular walls of the stomach, as appears especially in birds; and while he conceded a corrosive action of the stomach juices in some species, his followers denied all chemical digestion and regarded the whole process as purely mechanical.

During the eighteenth century the only additions to the knowledge of digestion were a few studies of the gastric juice.

René Antoine Ferchault de Reaumur (1683–1757) developed a new and fruitful method of investigation, publishing his results in 1752. He introduced metal tubes containing various food materials into the stomach of a buzzard (which, like other carnivorous birds, ejects from the mouth indigestible substances like bones, etc.) and other animals, and on examining them subsequently was able to determine the effect of the gastric juice on these materials. By using sponges in the tubes he was the first to obtain gastric juice in pure condition. He observed that meat and bone were dissolved by the gastric juice, but not grains or flour. He thus demonstrated that this secretion possessed a definite solvent power, distinct from putrefaction, and independent of trituration.

Employing Reaumur's and other similar methods, Lazaro Spallanzani (1729–1799), of Italy, continued and extended the observations, publishing his results in 1777 and subsequently. In 1777 Stevens, of Edinburgh, published a similar research. John Hunter (1728–1793) in 1772 and 1786 also published some observations on digestion.

The acidity of the gastric juice, appreciated by van Helmont and denied by his successors, was not generally recognized until the nineteenth century. Spallanzani and Hunter regarded the acidity of some of the specimens which they obtained as occasional or exceptional or abnormal only. Carminati recognized the real conditions, showing in 1785 that the gastric juice while fasting is neutral, and is acid only after taking food; his observations, however, did not gain general attention.

A contribution of interest to Americans, which, however, passed unnoticed, was the graduation thesis of John R. Young, of Maryland, at the University of Pennsylvania in 1803, in which he described experiments made on digestion in the stomachs of frogs and human subjects, and demonstrated the acidity of the gastric juice.

The foundations of our present knowledge of digestion were mainly established during the second quarter of the nineteenth century.

William Prout (1785–1850), of London, in 1824 identified the acid principle of the gastric juice as hydrochloric acid.

William Beaumont (1785–1853), an American army surgeon, from 1825 to 1833 conducted a celebrated series of observations of gastric

digestion through a fistula following a gunshot wound in the case of the Canadian Alexis Saint Martin, the results being published in 1833. These observations constituted an important contribution to the subject and attracted world-wide attention.

Leuchs in 1831 discovered the starch-digesting properties of saliva. Payen and Persoz in 1833 discovered and studied the amylolytic ferment diastase in germinating barley. Mialhe in 1845 isolated ptyalin from saliva.

J. N. Eberle in a work published in 1834 was the first to note the power of an extract or artificial gastric juice prepared from the gastric mucous membrane to dissolve proteid material. He, however, erroneously attributed this solvent action to the mucus on the surface of the stomach. Theodor Schwann (1810–1882), the discoverer of animal cells, investigated the subject (partly in association with his teacher Johannes Müller) and in crude form isolated from the gastric mucosa a principle possessing intense proteolytic powers, to which he gave the name pepsin; his results were published in 1836.

In his treatise published in 1834 Eberle noted the fact that a watery extract of the pancreas would emulsify oil, and he surmised that one of the functions of the pancreatic secretion was to favor the absorption of fat. In 1836 Purkinje and Pappenheim discovered that extracts from the pancreas possess proteolytic properties. In 1844 Valentin made some observations on the starch-digesting powers of the pancreatic fluid; and in 1845 Bouchardat and Sandras definitely demonstrated the secretion of an amylolytic principle by this organ.

Following these pioneer discoveries, the elucidation of the functions of the pancreas, especially its fat-splitting action, was accomplished chiefly by the work of the French investigator Claude Bernard (1813–1878), whose researches on this subject were prosecuted about 1836–1846.

From these beginnings the chemistry and physiology of digestion have been further elaborated by numerous subsequent investigators.

The study of gastric digestion was made a simple clinical procedure by the employment of the stomach tube for obtaining samples of gastric juice. This originated with Adolph Kussmaul (1822–1902), who in 1869 reported the use of the stomach tube in the treatment of dilatation of the stomach; subsequent to which the examination of gastric juice for diagnostic purposes was elaborated by W. O. Leube, C. A. Ewald and Franz Riegel, and their associates during the seventies and eighties of the last century.

Important studies of the action of the digestive organs were not long ago made by Ivan Pyotrovich Pavloff (often transliterated, from the German, J. P. Pawlow) (born 1849), director of the Imperial Institute of Experimental Medicine in Saint Petersburg, the results of whose brilliant researches (conducted 1887–1897) were first published in col-

lected form in 1897. For this work Pavloff received the Nobel prize in 1904.

The discovery of pancreatic secretin by William Maddock Bayliss and Ernest Henry Starling, announced in 1904, opened up an entirely new field of knowledge, that of the action of the so-called hormones as inciters of secretory activity carried to the points of action by the circulation.

The introduction of the X-ray made available a new and fertile method of studying the movements of the digestive organs; one of the earliest and most prolific workers in this field has been an American, Walter Bradford Cannon, professor of physiology at Harvard, whose contributions on this subject date from 1899.

The main basis of dietetics rests in the chemistry of food and nutrition. This knowledge could not be developed until the science of chemistry entered upon its renaissance, which occurred much later than the birth of modern anatomy, physiology and physics. The discovery of oxygen in 1774 opened the way to a rapid development of chemical knowledge, just as Harvey's discovery of the circulation a century and a half before had been the starting point for physiology.

As has been the case with many other discoveries, the effective discovery of oxygen had been anticipated long previously by work that had fallen into oblivion. In 1668 a young Englishman at Oxford, John Mayow (1645–1679), published a remarkable work in which he argued that the atmosphere contains, as he styled it, an "igneo-aereal" or "nitro-aereal" principle which by combining with combustible ("sulphureous") substances constitutes the process of combustion; that this principle is imparted to the blood by the respiratory activities; that the union of this principle, carried in the blood, with combustible material in the muscles gives rise to muscular action and is a source of animal heat. Though this theory was soon forgotten, it was a remarkable presentation of the doctrine of oxidation (including body oxidation as the source of animal energy), and anticipated by a century the discovery of oxygen.

In 1774 oxygen was independently discovered by Joseph Priestley (1733–1804), an English clergyman, and by Karl Wilhelm Scheele (1742–1786), of Sweden. It was Antoine Laurent Lavoisier (1743–1794), of Paris, however, who grasped the real significance of this discovery, and by his researches, published from 1775, overthrew the false though fruitful phlogistic theory of heat that had dominated chemistry for a century, and showed the true nature of combustion and the properties of oxygen.

Lavoisier was followed by a number of brilliant investigators, who rapidly laid down the great foundations of chemical science. The beginnings of organic chemistry may be traced to some of these early workers; Lavoisier, for instance, showed that organic compounds are

composed mainly of carbon, hydrogen and oxygen, and sometimes nitrogen.

The foundation and elaboration of organic chemistry was mainly the great achievement of the illustrious chemist Justus Liebig (1803–1873). After studying chemistry at Paris under Gay-Lussac, he was professor of chemistry at Giessen 1824–1852, and at Munich from 1852 until his death in 1873. About 1837 he began epoch-making investigations of physiologic and organic chemistry, and in works published from 1840 he laid down the main lines of our knowledge of the chemistry of food and nutrition. He first, for instance, sharply differentiated the foodstuffs albumen, fat and carbohydrate, and recognized the tissue-forming function of albumins and the heat-producing properties of fats and carbohydrates.

Since the time of Liebig many workers have brought our knowledge of the chemistry of food to its present state. Among important investigations of this character now being actively prosecuted are those on the molecular structure of the complex foodstuffs, such as the studies of Emil Fischer, Emil Abderhalden and others on the proteins. Some of the sugars have been artificially synthesized, and a beginning has been made even on the proteins.

Crude attempts at food analysis date back for centuries, as in connection with governmental measures to prevent adulteration of foods and beverages. In the modern era George Pearson, of England, in 1795 reported an analysis of potatoes; in 1805, Einhoff analyses of potatoes and rye. Reliable analyses of milk were reported by Peligot in 1836, and of feeding stuffs and milk by Boussingault and Le Bel 1836–1839. From about 1840, through the work of Liebig a great impetus was given to food analysis; and with the further advances of chemistry came the development of reliable analytic methods and the accumulation of data. From about 1860 the standard methods of food analysis now employed were developed by Wilhelm Henneberg (1825–1890), of the agricultural experiment station at Weende, near Göttingen; these methods soon came into general use and have greatly facilitated and systematized this line of work.

Possibly the earliest analyses of food made in the United States were of some cereals by C. U. Shepherd published in 1844. Analyses of various foods were published by Salisbury in 1848, Beck in 1848–1849, Emmons in 1849, Jackson in 1857. One of the most prolific workers in this field in this country was Atwater, who, employing the Weende methods, made analyses of maize in 1869, and commenced an extended series of analyses of fish and other foods in 1877.

Dietary studies—investigations of the amounts of foodstuffs actually consumed by different classes of people under various conditions—furnish an important part of the data underlying the science of dietetics. Among the earliest investigations of this sort were those conducted by

Liebig in 1840; by Beneke in England in 1851; and in this country by John Stanton Gould in 1852 and Atwater in 1886. Since then many such studies have been made and a large amount of information collected.

A knowledge of the processes of metabolism forms another component of the foundations of dietetics.

Probably the earliest real metabolism studies were prosecuted by Sanctorius (1561–1636), who published his results in 1614. Sitting in a chair suspended from steelyards, he observed the changes in weight from eating and from the loss of insensible perspiration.

Theories of the source of animal heat were presented from the early days of physiology. Van Helmont held that animal heat was generated by fermentation of the blood in the heart. Sylvius believed it to be produced by the supposed effervescence resulting from the mixture of venous blood with acid chyle. Mayow in 1668 anticipated the modern view that the body energy is derived from oxidation in the tissues; but his views were soon forgotten. Toward the end of the seventeenth century these chemical theories were largely superseded by the physical view that animal heat is generated by the friction of the blood in the capillaries. It was not until after the discovery of oxygen that our present conceptions of the part played by oxidation as the source of animal energy were founded by Lavoisier.

The general outlines of our knowledge of metabolism were formulated by Liebig, the details being worked out by numerous subsequent investigators, many of them under his personal influence. In this way, chiefly since 1850, an extensive mass of data on this subject has been accumulated. The earliest metabolism study appears to have been one by Lehmann, made in 1839. The study of the metabolism of nitrogen is a comparatively simple matter, and has been an easy and frequent subject for investigation.

The determination of the exchanges of carbon and hydrogen is a much more difficult matter, involving the collection of the products of respiration and requiring elaborate apparatus and an amount of labor rarely available. Early respiration experiments with animals were made by Boussingault about 1844, Bidder and Schmidt in 1847–1850, and Regnault and Reiset in 1849; and with man by Barral in 1847–1848, and Hildesheim in 1856.

A most extensive and accurate series of investigations was conducted by Max von Pettenkofer (1818–1901) and, especially, Carl von Voit (1831–1908), in the Physiological Institute at Munich with the respiration apparatus constructed by Pettenkofer about 1860. Animals and men were made the subjects of extended observation with this apparatus from 1861 to 1867, and principles of fundamental importance were established by these classical researches.

Other important studies of metabolism were prosecuted by Pflüger

and his associates in Bonn, by Zuntz in Berlin, by Tschudnovski, Pashutin, and others in St. Petersburg, by Tigerstedt in Sweden, and by many others.

The energy exchanges of the organism have a fundamental bearing in dietetics, since the heat output of the body under different conditions determines the caloric requirements of the diet. The apparatus used to investigate these exchanges, the respiration calorimeter, besides measuring the respiratory products after the manner of Pettenkofer's apparatus, determines with great accuracy the amount of heat given off by the subject. In its perfected form this mechanism is a marvel of complexity, elaborateness, and delicacy, requiring much labor and ample resources for its construction and operation.

Some imperfect calorimetric studies on animals and man were published by Russian observers from 1884. Max Rubner (1854–) was the first to conduct a successful and elaborate series of calorimetric observations on animals. He was educated at Munich under Voit; professor at Marburg 1885–1891; at Berlin from 1891, succeeding Koch as Director of the Hygienic Institute. His studies were begun about 1889, and his results published in full in 1902. He demonstrated that the law of the conservation of energy holds good for animals; and he has laid down principles fundamental in this branch of physiology and of the utmost importance in dietetics.

The most elaborate calorimetric investigations ever carried out have been those prosecuted in this country since 1892 by Wilbur Olin Atwater (1844–1907) and his associates and successors. Atwater studied at Munich under Voit, and derived some of his ideas from Rubner. Professor of chemistry at Wesleyan University, Middletown, Connecticut, from 1873 until his death, he devoted his whole life to investigations concerning food and nutrition. In 1892, with the assistance of the physicist Rosa, he began the construction at Wesleyan University of a respiration calorimeter large enough to accommodate a human subject. This apparatus underwent gradual improvement until finally direct determinations of the oxygen exchanges were, for the first time on a large scale, carried out. The work was jointly supported by Wesleyan University, the Storrs (Connecticut) Agricultural Experiment Station, the United States Department of Agriculture, and (later) the Carnegie Institution. With this apparatus an elaborate series of researches was carried out from 1892 to 1907, the results of which must stand as classical. After Atwater's death in 1907, the original apparatus was removed to Washington and installed in the Department of Agriculture, where it is now in operation; while his successor Francis Gano Benedict under a grant from the Carnegie Institution is continuing the research with an equipment constructed in Boston.

Other investigators have since taken up this line of work, and impor-

tant points concerning metabolism under different conditions and in various morbid states are now in course of elucidation.

To recount all the important researches on the physiology and chemistry of dietetics would unduly prolong this historical review. I have mentioned the principal contributions that have first opened up the various lines of inquiry pertinent to the subject. By the researches of a host of investigators along these lines have been accumulated the data and developed the principles that underlie the theory of dietetics as we have it to-day. The evolution of the subject is still far from complete, and points of even fundamental importance are yet to be worked out. So elementary a standard, for example, as the optimum daily ration of protein, is even yet unsettled. The establishment of rational principles of feeding in disease has been very incompletely accomplished. The whole subject is in a transitional stage; investigation is, however, proceeding rapidly, and results with important practical bearings are being constantly gained.

American conrtibutions to the subject have been noteworthy, such as the work of Beaumont, Atwater and Cannon. Honor is especially due to the United States Department of Agriculture for the special encouragement it has since 1894 given to the study of problems relating to the food and nutrition of man; under its auspices a vast amount of research has been systematically fostered all over the country and the results published and distributed in an extensive series of bulletins.

The scientific and rational principles of dietetics have not become well assimilated into the conceptions of the public, or even of the medical profession. Dietetics is a fruitful field for fallacy, fancy and fad. There are a few diseases that have a specific dietetic treatment, such as diabetes, acidosis, scurvy, beri-beri, gout, etc., in which, as also in infant feeding, the profession follows rational principles. With many diseases the appropriate dietetic principles are ignored, or have not been as yet worked out, or do not differ from those of health. In this field the dietetic management is to a certain extent a matter of caprice, guesswork and error. Faulty practises are in vogue, such as the general use as food of meat extractives and soups, although well known to be devoid of nutritive value. Mystic potencies and occult dangers are erroneously ascribed to articles of food. The distrust of food engendered in the ancient days of medicine still lingers, and there is no doubt that countless lives have been sacrificed to the fear of feeding in disease.

The medical students and practitioners of the present and future need to be more thoroughly grounded in the scientific and rational basis of dietetics. Only by a thorough appreciation and application of its principles can this subject be raised from a position of empiricism to that scientific dignity which it is the aim of modern medicine to attain, or the powerful agency of diet be utilized in its maximum efficiency for the benefit of mankind.

JEWISH COLONIZATION IN PALESTINE

By O. F. COOK
BUREAU OF PLANT INDUSTRY

HISTORICAL and religious interest has been responsible for many investigations and explorations in Palestine, but the country has still to receive an adequate study from the biological and agricultural standpoints. What we are pleased to describe as European civilization had its rise in western Asia and was based on the cultivation of plants indigenous in that region. The agriculture and agricultural plants of western Asia were brought to Europe in prehistoric times as a part of the equipment of the ancient Mediterranean civilization. To become familiar with the primitive stocks of our cultivated plants and the primitive agricultural arts that are still practised in this cradle-land of civilization is quite as interesting as reconstructing its ruined cities or digging out its buried inscriptions. We have much more adequate knowledge of incidents of ancient history than we have of the underlying agricultural and social conditions.

Even among those who have urged the colonization of Palestine for reasons of philanthropy and national patriotism there has been rather tardy appreciation of the importance of scientific exploration and investigation of agricultural resources. It remained for American Jews who have relatively little interest in the colonization idea to undertake the investigation of the country from the broader motive of human welfare, and as a means of securing for American agriculture the advantages of better knowledge of the agriculture of western Asia, whence so many of our American crops have come. There is a special reason why this agricultural knowledge is likely to be much more valuable in the United States than in Europe, for we have in our Pacific coast and southwestern states enormous agricultural resources still undeveloped under natural conditions that are much more Asiatic than European. In other words, we have need to go back to Asia to get the remainder of the agricultural plants and agricultural knowledge that was not carried to northern Europe because the European conditions were unfavorable. Thus the establishment of colonies of European Jews in Palestine has had the entirely unexpected result of opening the country to agricultural exploration in the interest of American agriculture.

The establishment of an agricultural experiment station in Palestine was announced in *Science* in 1909.[1] The director of this station,

[1] Fairchild, David, "An American Research Institution in Palestine. The Jewish Agricultural Experiment Station at Haifa," *Science*, N. S., 31: 376.

Mr. Aaron Aaronsohn, had already been engaged for many years in an agricultural and botanical exploration of the country, some of the results of which have been published in Bulletin 180, Bureau of Plant Industry, U. S. Department of Agriculture. One of the most interesting discoveries was a wild species of wheat closely related to some of the domesticated forms, and possibly representing the long-sought ancestral form of this whole group of cereals. An opportunity of observing the habits of this plant in the region of Mt. Hermon in the summer of 1910 has left no doubt that the plant is a genuine wild species, and not an escaped form of domesticated wheat. A subsequent experiment with the wild wheat in southern California shows that it is worthy of further study from the standpoint of acclimatization in the United States.[2]

But the wild wheat is only one of many subjects that are receiving attention at the newly established experiment station. Many difficulties are being encountered, as was fully expected beforehand, including the necessity of grappling with the problem of malaria. As this disease has been one of the most serious obstacles in the establishment of the colonies, the power to control it has a direct relation to the agricultural progress of the country. Some of the most fertile districts have remained almost uninhabited on account of the prevalence of malaria, a disease that modern sanitation can easily exterminate. The recent organization of a health bureau for the scientific study of the indigenous diseases and the improvement of hygienic conditions is the first outgrowth from the establishment of an agricultural experiment station.

Thus the founding of this station has given a new aspect to the whole colonization movement, in showing that the resources of modern science are to be enlisted. It is becoming apparent that some of the problems of Palestine will yield to scientific knowledge, although they may have resisted the most devoted efforts and the most liberal expenditure of money in unscientific ways. Motives of religion, charity and patriotism have figured so largely that constructive applications of science have received little consideration. If even a part of the colonists brought with them to Palestine a knowledge of modern scientific agriculture the situation would be entirely changed. Such knowledge would be far more precious than money, so much of which has been spent to little purpose.

The tendency has been to think of Palestine as a refuge from oppression rather than as an opportunity of developing a new agricultural civilization. But if the colonization movement continues it must be only a question of time when the traditional idealism of the people will assert itself in agricultural lines, as it has in so many other forms

[2] Cook, O. F., "Wild Wheat in Palestine," Bulletin 274, Bureau of Plant Industry, U. S. Department of Agriculture, 1913.

of human activity. The factor of time is indispensable in all such movements. The ancient Hebrews of the Exodus spent forty years in the wilderness before they were ready to adopt an agricultural existence, and it is a new generation nurtured in the wilderness of modern Palestine who now appreciate the need of a more effective conquest of the art of agriculture.

The persistence of the colonists in the face of so many difficulties naturally arouses interest in what might be accomplished if a people capable of so much devotion and self-sacrifice should really face the problem of developing an agricultural civilization adapted to the local conditions. As the colonists had not been farmers in Europe, the life they undertook in Palestine broke absolutely with all their previous existence. What the previous existence must have been can best be judged, perhaps, by what the colonists are willing to accept in Palestine as an improvement. The absence of agricultural knowledge or experience means that they must work at first at the greatest possible disadvantage, and encounter all manner of unnecessary toils and hardships that people with agricultural traditions would readily avoid. But even after incredible perseverance has overcome the handicap of unskillful and inefficient labor and brought material prosperity, the lack of agricultural ideals is even more apparent, for the colonists have still to appreciate and utilize the opportunities that are within their reach, in the direction of securing the normal advantages of agricultural life. And yet in some respects the conditions appear extremely favorable for progress along new lines. The very existence of the colonies is evidence of a strong determination to escape the artificial restrictions represented by the conditions of life in the European cities whence most of the colonists have come.

In the effort to resume a simple agricultural existence the colonists may be said to have gone back about 3,000 years to the time of the ancient theocracy, before the establishment of kingly government in the persons of Saul and David. The provisions of the law of Moses evidently contemplated the development of a purely agricultural civilization, and made no provision for the control of urban populations by a permanent centralized government. The modern colonies are also free from any attempt at governmental organization and it may be this that has enabled them to develop peaceably in the midst of a population traditionally hostile, but actually much more tolerant than many European communities.

The reasons of safety that might have impelled the early colonists to crowd themselves together in small slum-like villages no longer justify the continuance of such methods at the present time. The more settled state of the country and the development of telephones and other means of communication would make it possible for each family to live on its

own land under its own vines and fig trees. And even from the standpoint of safety more is to be gained by developing readier means of communication and transporation than by crowding the people into small inaccessible villages.

In spite of all that has been said of the devastation of Palestine, the country has rich possibilities of agricultural development. The prevailing notion that the Promised Land is now a hopeless desert rests largely on the impressions of travelers who confine themselves to the regular tourist route from Jaffa up to Jerusalem and then down to Jericho and the Dead Sea. The districts visited on such a trip give about as correct an idea of the country as might be obtained if a visitor to California were to land at Los Angeles or San Diego, and then travel over the mountains to Indio and the Salton Sea. Even the most recent account of Palestine, written by a professional geographer, shows a very inadequate appreciation of the factors that determine the agricultural possibilities of the country.[3]

The agricultural possibilities of Palestine are not likely to be appreciated by visitors from Europe and America until some readily accessible part of the country is developed on the basis of farm homes. People who live in crowded villages are not likely to attain any very high degree of agricultural prosperity or to make very rapid agricultural progress. What the colonists have been able to accomplish under their present methods of living affords ample evidence of a self-sacrificing determination, worthy, not of a better cause, but of a better course, more directly aimed toward agricultural improvement.

The natural conditions are undoubtedly favorable, and the desire for agricultural progress exists, but effective combination of the two elements must also be secured. The leaders among the colonists are no longer resting their hopes for the future upon securing political control of the country through purchase or diplomatic negotiations. Whatever the political status of the country the essential conditions will remain the same, in the sense that the whole resident population must be considered in any program that is to assure the permanent progress of the colonists. Thus the human problem is even more serious than the agricultural problem. The human environment of the colonists needs to be improved, no less than the agricultural environment. The only possible solution of either problem is through agricultural and

[3] See Huntington, E., "Palestine and its Transformation," 1911. This author considers it very unfortunate that most of the rain comes in the winter instead of in the summer season when the crops are growing, but overlooks the further facts that nearly all of the precipitation occurs in the form of very gentle rain, and that the granular limestone soil is extremely well adapted to absorb and retain the moisture till the crop season arrives. The sesame and sorghum crops grow without any rain, on moisture stored in the soil by dry farming methods.

educational progress. The improvement of agricultural conditions is the single issue on which the highly diversified population of the country might be expected to agree.

Whether any ordinary system of formal education in schools will have any practical result in Palestine seems very doubtful. Some parts of the country are already overstocked with different kinds of charitable and religious institutions, many of them engaged in educational work, but apparently with as little relation to the requirements of actual life as similar institutions in Europe and America. Though most of the colonists are already past school age when they arrive in Palestine, yet they are acutely in need of learning how to work and live in the new country. For effective agricultural education in a country like Palestine, there must be places where men, young or old, can acquire correct habits of doing farm work, become accustomed to the atmosphere of farm life, and learn something of its possibilities. Agriculture is a habit and a method of life, not merely a science to be studied or an art to be pursued for profit alone.

Agricultural education, in the narrow sense of formal scholastic instruction in agricultural facts, commonly fails to accomplish its intended purpose of improving the life of the farm. At the same time that the boys are being instructed in agricultural knowledge they may also be losing their agricultural habits and becoming less adapted to agricultural life. After their courses in agriculture they are more likely to enter some other line of activity involving less responsibility than agriculture and more similar to the work and life of the school to which they have become thoroughly accustomed. The unintentional training in town life usually has a stronger influence than the formal instruction of the school. The event proves the boy has been educated away from agriculture rather than towards it. Whether agriculture or other subjects are studied makes little difference in a comparison with the change of habits of life. Thus the general effect of agricultural schools and colleges in the United States has been to take more of the boys away from the farm, or, in other words, to make our civilization more industrial and commercial, rather than more agricultural.

Even less can be expected in Palestine than in the United States from the establishment of agricultural schools of the ordinary sort, because of the lack of previous agricultural contacts on the part of the students. The American student who has grown up on a farm and is thoroughly familiar with farm conditions is much more likely to project some of the new facts that he learns in the school against the background of farm life, but in Palestine most of the newly arrived colonists are without agricultural experience. They need practise in farm life and farm operations even more than they need instruction in agricultural facts.

The next generation also needs to be educated without losing its contacts with the life of the family and the farm. Otherwise the young men will go to Egypt to find employment as clerks or emigrate to Europe or America in search of better commercial opportunities, as they are now beginning to do. Ordinary school conditions are in the nature of a training for commercial life, but there is no corresponding training for agricultural life. This deficiency may be a more serious hindrance to agricultural progress among the Jews because of their stronger parental instincts. The greater the stress that is laid on the formal education the stronger the tendency to develop urban habits of school life in the children. To what extent this educational propensity may have interfered with the success of agricultural movements among the Jews would be difficult to determine, but it is evidently a factor at the present time. Though commonly considered as a non agricultural people, the Jews have clung to their agricultural traditions with wonderful tenacity and have made innumerable attempts to place themselves on an agricultural basis. It would be important as well as interesting to determine what has held them back.

The difficulties of agricultural education are not peculiar to Palestine. The same limitations to human progress are being encountered even in countries that have elaborate provisions for agricultural education. More practical methods must be found, that is, more truly human methods if the full possibilities of any country or any people are to be realized. The issue seems more acute in Palestine, in the presence of a people who have fled from the urban civilization of Europe, as their ancestors escaped from Egyptian bondage. Urban educational ideas must be left behind if the permanent deliverance is to be attained. If a solution could be found, in spite of the extreme difficulty of the problem, no movement of our times would command a wider interest. The world would owe a new debt to the Jew, and Palestine would become more than ever the historical background of our civilization.

THE NATIONAL ZOOLOGICAL GARDEN

By Dr. R. W. SHUFELDT

WASHINGTON, D. C.

MY home at the present time is within ten minutes' walk of the National Zoological Park at Washington, and, as a matter of fact, when my study window is open, and outside conditions are favorable, the howling of the coyotes and wolves, the barking of the seals, and the calls of the big birds of prey are, each and all, heard with delightful distinctness.

Zoological gardens and parks have interested me most keenly as far back as I can remember, and in years gone by I have published, in one place or another, a number of articles about them, in which I have attempted to point out what extremely valuable institutions they are to any civilized community of people.

Within the past few weeks I have made quite a number of photographs in the National "Zoo," including some of the principal buildings, the animals and views. Some of these were taken for a definite purpose, to which they have already been applied. Others were taken to help illustrate a book I am writing on animals; while a few have a special interest for me on other accounts, and some of these I am using to illustrate the present article, as, for example, the superb specimen of the Kadiak bear shown in Fig. 1. This is the largest carnivore existing on this planet to-day, and is, as in the case of so many of our famous mammals, gradually, but very surely, being exterminated.

There are a number of different species of bears in the collection of the National Zoological Park, as for example the brown bear of Europe, the black bear, grizzly, polar bears and others. They are placed upon exhibition by being confined in a series of cages, here shown in Fig. 1, with "dens" built in solid masonry and stone-work at their farther ends. Although well and regularly fed, and the general surroundings very beautiful, these poor fellows are by no means happy or contented. Bears are extremely active in nature, and delight in climbing trees and in cutting up all sorts of antics in the forests. These cages are doubtless the best that the limited funds at the disposal of the management will purchase; but any one who knows anything of a bear's needs, knows full well that it is a cruelty to keep them in such quarters as those in which they are now confined. These cages should be five or six times their present size, and running water should pass through them. There should be areas enclosed of soft ground for the bears to scratch and roll upon; and, above all, a number of trees, as large as possible, should be enclosed, in that they could climb to their heart's content. It is a truly pitiable sight to see these poor creatures try to "kill time" in

every way that their tortured ursine minds can devise in these big rat-traps.

No one appreciates these facts more keenly than Dr. Frank Baker, the present superintendent of the gardens, and Mr. Blackburne, the head keeper—a big-hearted man who *knows* animals, and feels for them as though they were his own captured and caged relatives. But the fault does not altogether lie in any such quarter; for, were the necessary

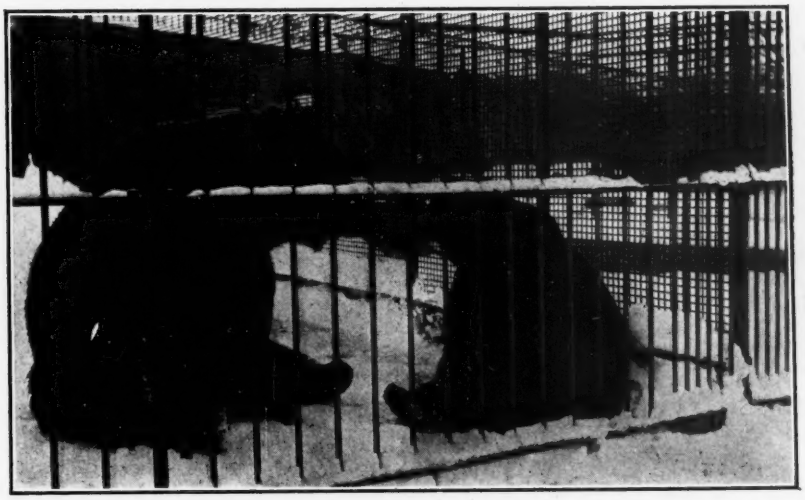


FIG. 1. THE KADIAK BEAR; the largest carniverous animal in the world.

amount appropriated by congress every year to make this park what it really should be, a credit to the American nation and an educational center of the greatest magnitude and importance, no such daily, hourly acts of cruelty would be perpetrated, and the kind of article I am now writing would never have been thought of, much less penned.

It is truly a marvel that so much has been accomplished at our "Zoo" with the meager means that the government allots for the purpose. This year $100,000 has been appropriated for the purchase of more land to be added to its present acreage, which is something,—a step in the right direction for the future; and were it backed up by half a million more, to be expended on what is now possessed and on its inhabitants, it surely would be a matter for national congratulation. But with salaries that would make a car conductor blush to receive; a third of the rare animals housed in hat-boxes; *no aquaria* or reptile house worthy of the name,—it's no wonder we are criticized. The idea of a park, a "zoo" like ours, with no photographic gallery, and no prosector or anatomical laboratory and work-rooms!

One of the grandest sights in our National Park at Washington is the great flying-cage for large-sized living birds. This immense wire structure is no less than 150 feet long, and 50 feet high and wide. I

have photographed it both inside and out, and reproductions of these photographs are here shown in Figs. 2 and 3.

The picture shown in Fig. 3 gives a good idea of the interior of this elegant structure, which is situated in a very attractive spot, the surroundings being forest, stream and wooded hillside. Two black-bellied tree ducks (*Dendrocygna autumnalis*) are seen at the edge of one of the swimming pools in Fig. 3, and fine examples of pelicans, water turkeys, night herons, gulls, cranes, storks and their many allies live most happily in this enormous and attractive cage,—indeed, so attractive has it been made, and in such a secluded spot, that the wild herons come every year and build their nests on the top of it, in the vines there running over the wire. It is truly a grand sight and one of the redeeming features of the place.

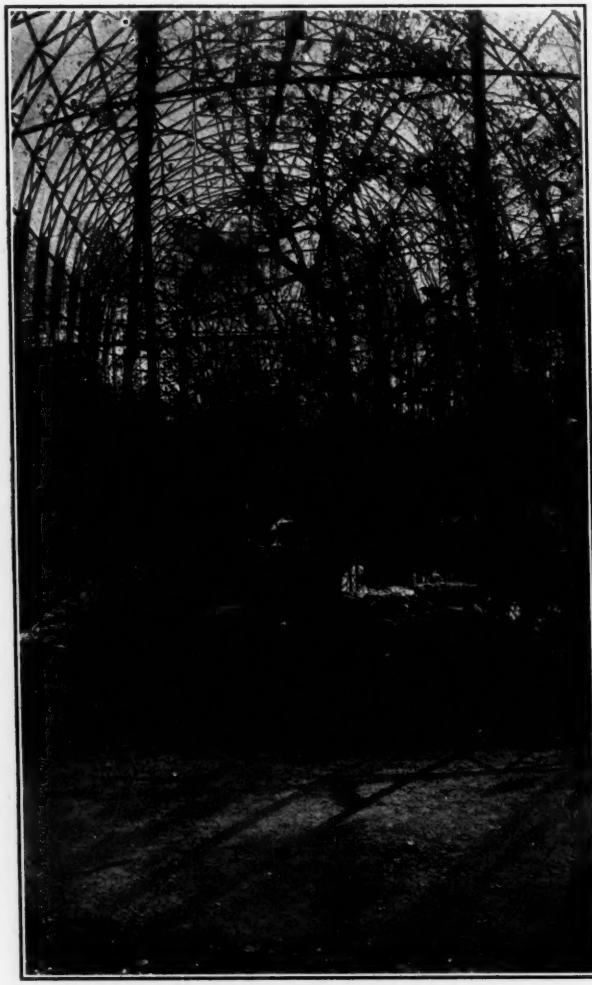


FIG. 2. THE FLYING-CAGE FOR LARGE BIRDS.

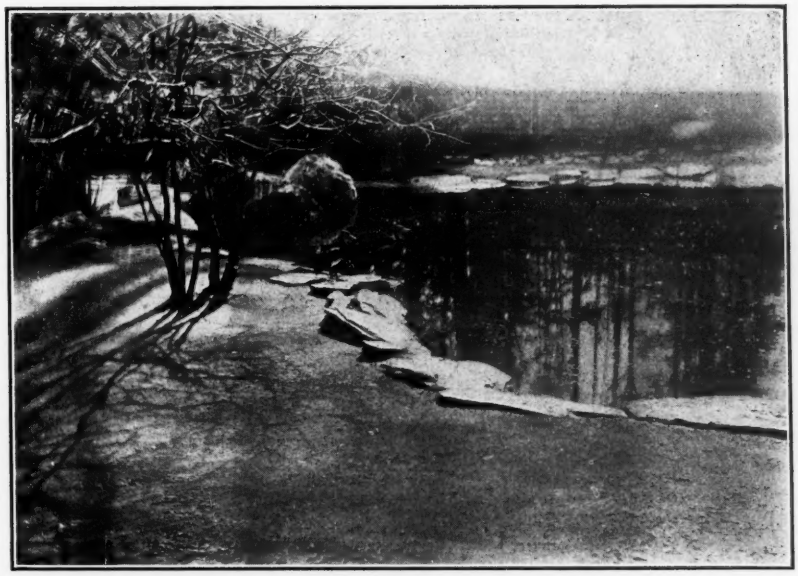


FIG. 3. SCENE INSIDE OF FLYING-CAGE.

Some of the paddocks for deer, moose, caribou and the like are as fine as can be found anywhere in the world, and the animals inhabiting them are probably as contented and certainly as comfortable as their relatives enjoying their freedom in their native wilds. One of my pictures (Fig. 4) gives a view of one of these paddocks in which deer are confined; it is just this side of the flying-cage, which may distinctly be seen through the trees in the background. There is a beautiful bunch of deer in sight, and it is easy to recognize the ideal conditions under which these elegant animals are kept. Even the skeleton wire-fence which surrounds their paddock fails to mar the general effect of the naturalness of the locality, which is greatly enhanced by the attitudes assumed by the deer, each being the very exemplification of alertness and curiosity as to the intentions of the photographer.

All the animals at the park, however, are by no means living under such ideal conditions; in fact, the lives led by some—altogether too many of them—are fit subjects for the action of the Society for the Prevention of Cruelty to Animals, and it is only a short time ago that the secretary of the Smithsonian Institution was compelled to print in his annual report that

> It has been possible to make some needed improvements in the roadways of the park during the year, but many of the buildings are almost falling down. The need of means to put a permanent shelter over the animals can not be overstated. Mention has already been made in this relation of the aquarium building, which consists of a literal barn, and which was brought here until Congress could provide a special one; but although several years have elapsed, none has yet been provided. The elephant house, a small wooden shed, put up

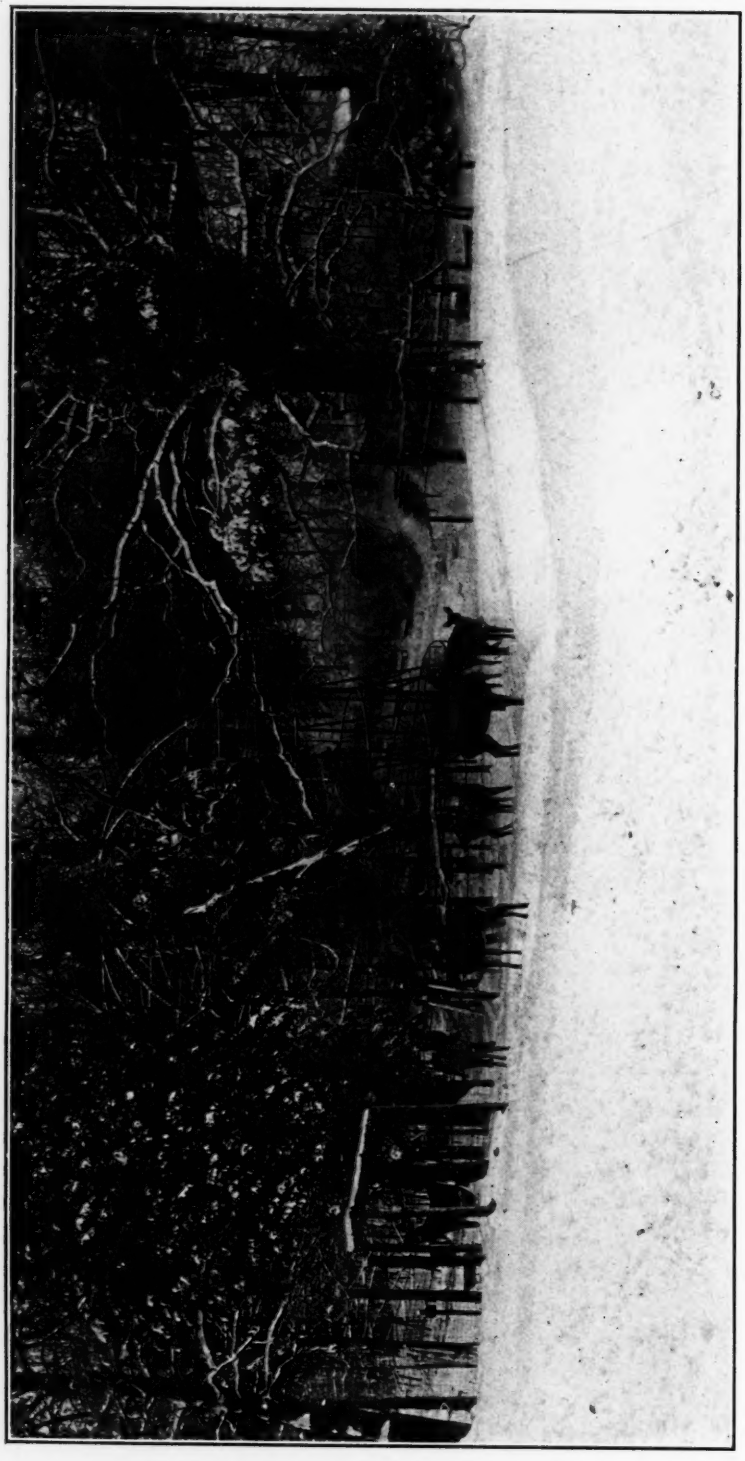


FIG. 4. ONE OF THE DEER PARKS IN WINTER.

as a temporary expedient ten years ago, requires extensive repairs to prevent it literally falling from rottenness.

As I say, the aquarium project has now been abandoned, and a nation of 90,000,000 of people must be satisfied with the dozen or more well kept, thoroughly inadequate and small aquaria at the building of the U. S. Fish Commission in Washington as the extent of the facilities for the study of living fishes in confinement; a few trout, turtles, bass, and *gold fish* which, as far as they go, in a measure instruct the people, and *certainly* amuse the scientists. But when we come to think what an immense problem in economics our fisheries presents, and how vitally important it is for us to study them in every possible way, both in nature and in aquaria, the negligence of congress in not amply appropriating money for the proper and extended prosecution of such enquiries by the scientific staff of the government is simply an indication of national inefficiency, and one of the trade marks of a backward, second class civilization.

At present, the one eagle cage that has been built is very good, as far as it goes; it has, however, been filled to its maximum capacity, and we find a superb specimen of the South American condor and a harpy eagle of great value cooped up in miserably small quarters, where, in the case of the latter bird, he can not enjoy the sunlight that his very nature craves.

Every intelligent naturalist and psychologist knows what wild animals of all kinds hourly suffer when confined for months—sometimes for several years—in small cages, pits and pens; their mental suffering is terrible, and only equaled by that endured by some highly educated person similarly confined. It is by no means an elevating sight to watch the pitiable efforts they make to relieve the terrors of what amounts to a great deal more than the mere loss of liberty; for it often means to them loss of companionship, sunlight, proper exercise, adequate amusement, and everything else that conduces to make even the life of a monkey or an elephant worth living. Still, if we close our eyes to all this and continue to hope that we may, some day, really have a congress that will appreciate these things, and do its duty by them, there is much to learn by a visit—or many visits—to our National Park.

Apart from my studies of the many animals there, it has, ever and anon, been a matter of delightful surprise and satisfaction to me when, at some unusual time and perhaps only two or three people—aside from keepers and others—could be found in the place, I have come upon some enthusiastic boy, vigorously at work with pencil, color or brush, in front of one of the cages, doing his best to faithfully portray its inmate. Ah, I've thought to myself then, may be a coming American animal painter; and, if it really turns out to be so in the future, not a few of the thousands of dollars congress has appropriated for this necessary project

will have been more than well expended; for a world-wide known painter of animals is calculated to shed more real credit upon a nation than is an entire army of imported criminal good-for-nothings down in the east side of New York City or any other American city. All this likewise applies most forcibly to the nature classes we occasionally see at the Zoo,—the sculptor in search of correct poses of animals for his art; the scientific taxidermist; the artist and the biologist, and an hundred others of the classes that make up the great scientific, artistic and learned body of people of the country.

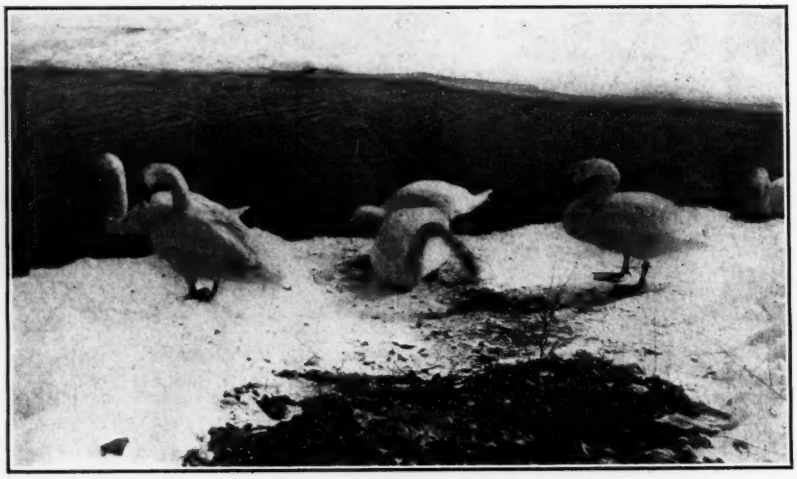


FIG. 5. WILD SWANS IN WINTER. (Feeding Grounds.)

We must be patient, however, and all will come to pass in due time; even congress delights in making generous appropriations to national *successes,*—but to make the venture a veritable success, there's where the rub comes.

What we really need, in addition to what has already been put on foot at our National Park, is the establishment, on a broad basis, of a thoroughly equipped department of photography for the animals kept there, and what is even more important, a department of anatomy, with a recognized anatomist at its head. It should be his duty to make as complete a report as possible on the anatomy of every animal that dies at the park, and such reports should be fully illustrated and prepared for publication in any appropriate government avenue. There should also be a laboratory established for this purpose, and such material as came to the dissecting table worthy of preservation should, together with the skeleton of the animal, be sent to the National Museum for the department of comparative anatomy—a department that, at one time, was the envy of scientific Europe and the greatest possible credit to American science.

THE DISCOVERY OF CONTACT ELECTRIFICATION

By Professor FERNANDO SANFORD
STANFORD UNIVERSITY

THE discovery that the mere contact of two dissimilar metals causes them to become oppositely electrified seems to be everywhere attributed to Volta, though Nicholson in the first volume of his "Journal," published in 1802, calls attention to the fact that both Bennett and Cavallo, in England, had made experiments upon contact electrification previous to its supposed discovery by Volta. The fundamental experiment from which Volta made this discovery is said by Auerbach in Winkelmann's "Handbuch der Physik" to have been announced by Volta in 1795, in Gren's *Neues Journal der Physik,* Vol. II., p. 144. The experiments which Volta, himself, seems to have regarded as fundamental in his theory of contact electrification were published in a postscript to a letter to Gren in Volume IV. of the *Neues Journal.* These experiments were not only the same in character, but were performed in the same manner and by means of the same apparatus as experiments which had been performed about ten years earlier by Bennett, and which had been published in a book to which Volta was a subscriber.

The actual discoverer of contact electrification seems to have been the Rev. Abraham Bennett, curate of Wirksworth, Derbyshire, who is known in the history of electricity as the inventor of the gold leaf electroscope, which still bears his name, and of a multiplier for increasing by induction the intensity of a given charge so as to render it measurable by an electroscope.

In 1789 Bennett published a small book entitled "New Experiments on Electricity," in which he gives an account of many of his discoveries and describes the construction of his electroscope and doubler, as well as the mechanical improvements made in the latter by Dr. Erasmus Darwin and William Nicholson. This book was published by subscription and contains a list of 394 subscribers, including many of the best known scientific men of the day, and among the rest, "Mr. Volta, Professor of Nat. and Exp. Philosophy." Volta had then been for ten years a professor in the University of Pavia, and had corresponded for some years with English physicists, notably Priestley and Cavendish, and only two years later was made a foreign member of the Royal Society.

Section VII. of Bennett's book is devoted to "Experiments on the Adhesive Electricity of Metals and Other Conducting Substances." In performing these experiments Bennett made use of Nicholson's improve-

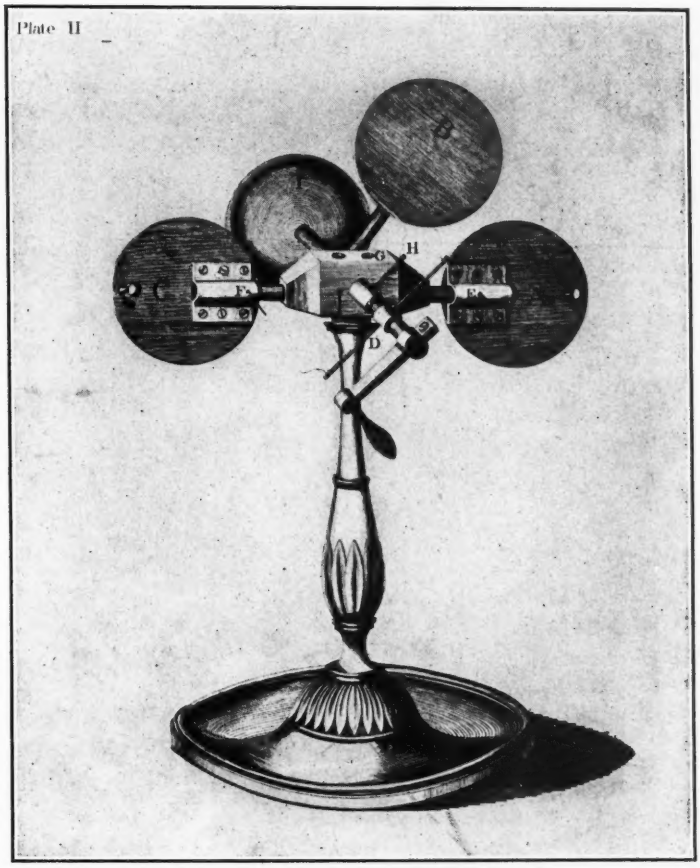
ment upon his own "Doubler," an invention which he had described in Vol. 77 of the *Philosophical Transactions*. Previous to this Volta had increased the sensitiveness of an electroscope by mounting condensing plates upon it, and Cavallo had still further increased its sensitiveness by using a double condenser. Bennett's first doubler consisted of three brass plates, one of which was mounted upon the standard which supported the gold leaves of his electroscope. The others were provided with insulating handles and were varnished on one side. When the electroscope had been given a small charge, one plate was laid with its varnished side upon the electroscope plate and touched with the finger. It thus received by induction a charge opposite to the charge of the electroscope. It was then raised from the electroscope by its insulating handle, and the other plate was laid with its varnished side upon it and touched with the finger. It accordingly received by induction a charge like the charge of the electroscope. It was then touched by its edge to the electroscope plate with which it divided its charge. Both unmounted plates were then discharged, and the process was repeated. By sufficient repetition the charge of the electroscope could be built up to any desired intensity.

Bennett's doubler was improved by Dr. Erasmus Darwin by mounting the plates upon horizontal arms which could be swung into and out of position readily, and later by mounting the plates vertically and moving them back and forth by a rack work in a direction always parallel to each other. In this form it was used by Darwin in the study of atmospheric electricity.

Bennett had noticed that his plates nearly always had a residual charge of electricity which made it possible to build up a charge on his electroscope without giving it a preliminary charge. To get rid of this he improved Darwin's form of the doubler by leaving the plates unvarnished and depending upon the air for insulation. He found that this made it possible for him to thoroughly discharge the apparatus, so that no charge could be built up until a preliminary charge had been given to the electroscope.

Soon after this Nicholson built a doubler in which two of the plates were fixed and the movable plate was mounted on an arm and turned about an axis by a crank, by which the proper contacts were also automatically made. This doubler Nicholson presented to Bennett, and it was used by him in his investigation of the "adhesive" effects of electricity. Bennett's original figure of this doubler is here reproduced. In this figure *A* is the fixed plate which remains permanently insulated and upon which it was desired to build up the charge. *B* is the movable plate which is carried on an arm from an axis which may be turned by a crank, and *C* is a fixed plate which may be either insulated, joined to *A* or joined to earth. *I* is a ball which serves to counterpoise the crank

and the plate B so that B may be stopped in any position. When the crank is turned B passes alternately in front of and parallel to A and C. The contacts are so arranged that when B is parallel to A it is joined to earth and so charged oppositely to A. It is then revolved in front of C, at which instant C is joined to earth and is charged by induction oppo-



sitely to B and like A. As B again comes in front of A, A and C are joined and B is earthed. B now receives by induction a greater charge than before, since A has now received the greater part of C's charge. By successive revolutions of B the charge may thus be built up to any desired intensity upon A.

Bennett performed many experiments with this doubler, and after learning how to discharge it completely he tested the electrification induced upon metal plates by being placed in contact with various substances, both solid and liquid. He concludes that different substances "have a greater or less affinity with the electrical fluid," and he then

undertakes his experiments on this adhesive affinity in the case of different metals.

At the beginning of Section VII., page 91, he says:

> Having fully proved by a frequent repetition of experiments, that the positive or negative spontaneous charge of the doubler depended upon the absorption or repulsion of the electrical fluid by the approximation of its parallel plates, and that by applying larger plates covered with minium or flour its electricity might be changed at pleasure, it easily occurred, that if the spontaneous electricity in the beginning of the process was sufficiently weak, the mere contact of metals or other substances having a different adhesive affinity with the electrical fluid might also change it, and a new and interesting employment for the doubler be discovered.
>
> This supposed effect of contact was confirmed by the following experiments, in which the doubler and electrometer were deprived of electricity, and used with the precautions and improvements mentioned in the last section.
>
> EXPERIMENT I
>
> The spontaneous charge of the doubler having been negative, and being deprived of this charge by the usual method, the plate *B* was placed parallel to the plate *A*, but so that *B* was not connected with the earth. The plate *A* was then touched with the blade of a knife, and the plate *B* at the same time touched with the point of a soften'd iron wire. With sixteen revolutions the gold leaf diverged about one third of an inch positively.
>
> EXPERIMENT II
>
> The doubler being deprived of electricity as before, and the plate *B* placed as in the last experiment, the knife was applied to *B* instead of *A*, and the soft iron wire to *A* instead of *B*, which opened the gold leaf negatively at 15 revolutions.
>
> These experiments were repeated very often, and the electricity changed each time, being always positive in the plate touched by the knife.
>
> To distinguish so minute a difference of adhesive electricity, as that which might be supposed between two metals so nearly alike as hardened steel and soft iron, wou'd appear incredible had not the frequent repetition of experiments confirmed it.
>
> Being now well convinced of this fact I tried many other substances with various success, sometimes the charge wou'd change regularly for a long time together, by applying the opposed substances to *A* and *B* alternately, as in the above experiments; and sometimes with other substances the charge wou'd be quite uncertain.

Bennett gives his experiments with six pairs of substances, each pair being tried about ten times. The charges given by contact to the plate *A* of the doubler were as follows: steel +, ironwire —; lead ore +, lead —; lead —, iron wire +; lead ore +, iron wire —; tinfoil —, iron wire +; zinc —, iron wire +.

He then tried charging the plate *A* of his doubler by a single substance while *B* was earthed. He found *A* to take a positive charge from

lead ore, gold, silver, copper, brass, regulus of antimony, bismuth, tutenag, mercury, various kinds of wood and stone. Zinc and tin gave negative charges to his plate.

Here is apparently the beginning of that arrangement of substances which has since come to be known as Volta's Contact Series. It is well to bear in mind that these experiments were published in 1789, two years before Galvani made his celebrated observation on the twitching of frogs' legs which finally led up to the controversy through which Volta discovered the electric current.

The next experimenter to investigate the subject of contact electrification was apparently Tiberius Cavallo. Cavallo was an Italian by birth, but was a resident of London and a prominent member of the Royal Society. Cavallo published "A Complete Treatise on Electricity," which went through a number of editions. In the fourth edition, published in 1795, he adds a new volume containing the important discoveries in the subject since the publication of the third edition. Among these he gives first place to the investigations of Galvani and Volta on animal electricity, and mentions the fact that Volta suspected the phenomena might be caused by the contact of two dissimilar metals. He refers to Bennett's experiments, but says that others who have repeated them have obtained inconstant results. Finally he hit upon a different method of experimentation which enabled him to detect with certainty the electrification due to metallic contact. In his section devoted to experiments on metallic substances he says:

> After many fruitless attempts, and after having sent to the press the preceding part of this volume, I at last hit upon a method of producing electricity by the action of metallic substances upon one another, and apparently without the interference of electric bodies. I say apparently so, because the air seems to be in a great measure concerned in those experiments, and perhaps the whole effect may be produced by that surrounding medium. But though the irregular, contradictory, and unaccountable effects observed in these experiments do not as yet furnish any satisfactory theory, and though much is to be attributed to the circumambient air, yet the metallic substances themselves seem to be endowed with properties peculiar to each of them, and it is principally in consequence of those properties that the produced electricity is sometimes positive, at other times negative, and various in its intensity.
>
> The discovery of those properties of metallic bodies opens a new field of useful investigation, and renders more manifest the general or extensive influence of a fluid wonderful in its nature and action. But how far they will enable us to explain the phenomena of animal electricity, and of other operations of nature, are considerations which will be noticed after the recital of the experiments.—In this account I shall endeavor to select and methodise the experiments, in the best manner that the irregularity of their results seems to admit of.
>
> Exp. I. A piece of zinc, which weighed little more than half an ounce, was dropped ten times successively upon an insulated tin plate. This plate was then brought in contact with the plate *A* of the multiplier: the lever was worked, and

after ten additions of electricity, the plate C[1] communicated to the electrometer a sufficiently sensible quantity of positive electricity, which shows that the tin plate had been electrified negatively by the contact of the zinc. This experiment was repeated four times within the space of half an hour, and was constantly attended with the like effect; but on the following day the effect was found to be less conspicuous, for three times twenty additions just enabled the plate C to communicate a sensible degree of positive electricity to the electrometer. In short, the different states of the atmosphere seem to be much concerned in the result of this experiment, and yet the whole effect can not be attributed to it; but of this further on. Before, however, I proceed to the narration of other experiments, it will be necessary to dwell a little longer on the above-mentioned operation, not only to render it more intelligible, but likewise to avoid repetitions.

The tin plate used in the preceding as well as in many of the subsequent experiments, measures eight inches in diameter; and is fastened to a small piece of wood about three inches in length. Two glass sticks covered with sealing-wax are cemented into this piece of wood, and their other extremities are cemented into a larger piece of wood, which forms the stand or basis of the instrument. The operation is as follows: I hold this apparatus by the last mentioned piece of wood in my left hand, and keeping the plate in an horizontal situation, let the piece of zinc or other metallic body, fall upon it from my right hand, which I hold a few inches above the plate; then by inclining or shaking the plate, the piece of metal is caused to fall upon the table or upon a chair; from whence I take it up, and again let it fall upon the tin plate, and so on.

Cavallo repeated this experiment with a considerable number of metals, and with great precautions to guard against any other source of electrification. He found that repeated touching with an insulated body gave no greater effect than a single contact. He tried lifting his pieces of metal with iron tongs, or in a metal spoon, and found that in some cases this changed the sign of the electrification. He then performed a long series of experiments on the effect of heating the metals, and found a change in their electric properties due to temperature. In the case of bismuth, he was able to change the sign of the electrification produced on the tin plate by heating the bismuth very hot. His experiments upon the temperature change in contact electrification were almost the only ones made for a hundred years, and were probably the most important ones that have yet been published. At the end of his experiments he stated the following conclusions:

1. The contact of one metallic substance with another generally produces electricity.

2. The quantity and quality of the electricity so produced, is various according to many circumstances which seem to concur in the production of it, or in great measure to influence it.

3. Those circumstances are, the various nature of the metallic substances, their various degrees of heat, the state of the atmosphere, and the other body concerned in the experiment, viz. the hand of the operator, etc. Each of those causes has a share in the result of the experiment; for the variations of any one of them, when everything else remains unaltered, produce different effects. Thus in different states of the atmosphere, the very same metallic substances treated

[1] Cavallo used his own form of multiplier in which the plates were not named as in Bennett's figure.

in exactly the same manner, produce a greater or less quantity of electricity. Thus also, by only heating or cooling the metals, the electricity may be varied in quantity and even in quality.

I am inclined to suspect, that different bodies have different capacities for holding the electric fluid, as they have for holding the elementary heat; if however the experiments relative to this subject be carefully tried, under all the variety of circumstances which the combination of the above-mentioned causes is capable of producing, I do not doubt but that all the phenomena observed in the preceding pages may hereafter be reconciled to one, or to a few, simple laws, which will at the same time assist the farther investigation of the science of electricity.

These experiments of Cavallo's could not have been made later than the year of publication, viz., 1795. While Cavallo says in his discussion of animal electricity that Volta suspects that the phenomena of muscle contraction which Galvani and he were studying might be caused by the contact of the two dissimilar metals which were used in making the connection between the muscle and the nerve in many of their experiments, yet Volta seems not to have actually experimented with contact electrification until after the publication of Cavallo's treatise, and then to have begun with the repetition of Bennett's experiments made ten years before.

There seem to be many diverse statements as to how Volta arrived at his theory of contact electricity, but his own story of it is given in a so-called letter to Dr. Gren, which was published in volumes III. and IV. of Gren's *Neues Journal der Physik,* in the years 1796–98. These journals are not accessible to the present writer, so their exact date can not be given, though Vol. IV. was concluded in 1798. Volta's letters to Gren are translated in the *Philosophical Magazine* of 1799, from which the extracts here given are quoted.

In the first part of Volta's letter, which was published in Vol. III. of Gren's *Journal,* Volta says:

The contact of different conductors, particularly the metallic, including pyrites and other minerals as well as charcoal, which I call dry conductors, or of the *first class,* with moist conductors, or conductors of the *second class,* agitates or disturbs the electric fluid, or gives it a certain impulse. Do not ask in what manner: it is enough that it is a principle, and a great principle. This impulse, whether produced by attraction or any other force, is different or unlike, both in regard to the different metals and to the different moist conductors, so that the direction, or at least the power, with which the electric fluid is impelled or excited, is different when the conductor *A* is applied to the conductor *B,* and to another *C.* In a perfect circle of conductors, where either one of the second class is placed between two different from each other of the first class, or, contrariwise, one of the first class is placed between two of the second class different from each other, an electric stream is occasioned by the predominating force either to the right or to the left—a circulation of this fluid, which ceases only when the circle is broken, and which is renewed when the circle is again rendered complete.

Farther along he says:

We might consider this mutual contact of two different metals as the immediate cause which puts the electric fluid in motion, instead of ascribing that power to the contact of the two metals with the moist conductors. . . . In both suppositions the result, as may be easily seen, is the same. But though I have reasons for adopting the first as true rather than the second, yet the latter represents the proposition with more simplicity, and it may be convenient to adhere to it in the explanation, as it affords a readier view of it.

In a postscript to this letter published the next year (1797 or 98) Volta says:

Some new facts, lately discovered, seem to shew that the immediate cause which excites the electric fluid, and puts it in motion, whether it be an attraction or a repulsive power, is to be ascribed much rather to the mutual contact of two different metals, than to their contact with moist conductors. But though it can not be denied that in the latter case there exists an action, it is proved that it exerts itself in a far more considerable degree when two metals mutually touch each other. There arises by the mutual contact, for example, of silver and tin, an action or power by which the former communicates the electric fluid, and the latter receives it; or the silver suffers it to escape and the tin attracts it. This produces, when the circle is rendered complete by moist conductors, a stream, or continual circulation of the fluid. When the circle is complete, there is an accumulation in the tin at the expense of the silver; which indeed is very small, and far under the point necessary to enable it to announce itself by the most delicate electrometer. I have however been able, by the assistance of my condenser, constructed on a new plan, and still better by Nicholson's doubler, to render it very perceptible: I shall here communicate the result obtained by my experiments, which I made some time ago with great satisfaction.

Exper. I. The three plates of the doubler are of brass. I took two strong wires, one of silver and the other of tin, and brought the former into contact with the movable plate, and the other with one of the fixed plates; while they both rested on the table, or, what is better, on moist pasteboard, or any other moist conductor, so as to be in communication by the intervention of one or more conductors of the second class. I suffered the apparatus to remain some hours in this state, then removed the two wires and put the machine in motion. After 20, 30 or 40 revolutions (or more when the atmosphere was not dry, or the insulation imperfect) I brought one of my straw electrometers into contact with the movable plate, and observed indications of positive electricity ($+E$) which arose to 4, 6, 10 degrees, and more. If I suffered it to touch the fixed plates, I had the corresponding indications of the opposite kind of electricity ($-E$).

The silver, therefore, poured the elastic fluid into the brass plate when it had been some time in contact with it; and the tin attracted it from the other plate, which was also of brass, while in contact with it. This was confirmed by the following experiment, which is a real *experimentum crucis*.

II. I reversed the experiment, so that the silver was in contact with one of the fixed plates, and the tin with the moveable one. The electricity which I obtained from the latter, after the apparatus had remained a sufficient time in that position, was negative ($-E$); while that of the fixed plate was positive ($+E$).

III. This is the reverse of the former. The piece of tin was applied to one of the fixed plates, and the moveable one was insulated from all metallic

contact. The result was now reversed; that is, the fixed plates were electrified negatively, and the moveable one had positive electricity.

Volta then varied the experiments, just as Bennett had done, by applying the tin wire only to the movable plate and testing its charge, and then to the fixed plate, and repeating the process. He then replaced the movable brass plate of the doubler by a tin plate, and using brass and tin wires for touching the plates, he found that he got a charge by touching his brass plate with a tin wire and his tin plate with a brass wire, but got no effect when he touched the plates with wires of their own metal. He then says:

> We must therefore conclude that the contact of two metals of a different kind with moist conductors, without the mutual contact of these metals themselves (which is wanting in the sixth experiment, where brass is in contact with brass, and tin with tin), produces nothing or almost nothing; and that, on the contrary, the mutual contact of the two metals of a different kind, which takes place in the fifth experiment, produces the whole, or almost the whole, effect.

The above considerations seem to make it certain that though Volta was apparently the first to recognize the existence of a current in a circuit composed of two metals and an electrolytic conductor, he has no claim to be regarded as the first discoverer of contact electrification. This honor should undoubtedly be accorded to the Rev. Abraham Bennett, while the discovery of the variation of the phenomenon with temperature is due to Tiberius Cavallo.

THE APPLICATION OF THE PHYSIOLOGY OF COLOR VISION IN MODERN ART

By HENRY G. KELLER
CLEVELAND SCHOOL OF ART
AND
Professor J. J. R. MACLEOD
WESTERN RESERVE MEDICAL SCHOOL

Introduction

LEONARDO in his treatise on painting says:

> Those who become enamored of the practise of the art without having previously applied themselves to the diligent study of the scientific part of it, may be compared to mariners, who put to sea in a ship without rudder or compass and, therefore, can not be certain of arriving at the wished-for port. Practise must always be founded on good theory.

Instead of serving as an incentive to more extensive study of the use of colors in art, these words seem to have marked the advent of an epoch extending over several centuries, during which colors came to be less and less successfully employed. The ideals of art came to be dictated by the academic painter and they were much more mythological and allegorical than founded on the beauty of color patterns. Much of art became black painting, little attempt being made to use pure colors even in landscape painting, and no consideration being given to the effects which could be produced by the influence of juxtaposed colors on one another. With the exception of some masters the ideal of artists was merely to reproduce as closely as possible the color tones and values as seen in nature—to produce a colored photograph without adding to it that mysterious something for which is responsible the peculiar charm and strength of the paintings of the early Italian masters and of the Chinese and Japanese, and which includes some subtle influence of the picture itself quite apart from what it represents; something that endows it with a charm that is all its own, and which no colored photograph can ever contain.

It is true that from time to time in the history of modern art masters have arisen who have, intuitively as it were, produced pictures the color schemes of which have contained this "something." But it is the individual rather than the system that has been responsible, and no attempts have been made until comparatively recently to evolve new principles for the use of colors which would serve as a guide to all; nor indeed was such an evolution possible until some progress had been made in the scientific interpretation of color. This progress is itself only of comparatively recent date.

At the present day there is an unrest in the world of art, an unrest which has resulted in the creation of innumerable schools, each endeavoring by some peculiar method of its own to inculcate new principles and to establish new ideals. Within a short period of time realism has given place to impressionism, impressionism to post-impressionism, and this again has become parent for so many other "-isms," that, to follow them, has become almost impossible. However unpictorial from our ordinary viewpoint the creations of some present-day artists may appear to be, there is nevertheless in many of them some newly discovered truth; they are the steps in an evolution, and we may hope that some day the evolution will be consummated and that from out of the apparent chaos, which at present exists, a really compelling picture will be created.

It is most of all in landscape painting that the evolution of modern art can be seen. The old landscapes of Claude Lorrain and Constable are no doubt full of charm, but they entirely lack the atmosphere and force of the so-called impressionist paintings of Monet, Sisley, Pissaro, etc. In the older landscapes an attempt was made to copy everything that could be seen by prolonged study, and the canvas was covered with detail to its very edges; in impressionism, it is merely the flash, the fleeting effect of the landscape which it is attempted to reproduce. There may indeed be considerable detail in certain portions of the picture, but the greater part is merely a color pattern. But after all such an impressionistic picture can occupy our attention for a moment only. We do indeed receive an impression more or less like that which the artist received on viewing his object, but closer study of the picture does not carry us farther; there is something absent from it with which nature abounds, something that compels us, as when viewing a landscape, to keep shifting our gaze from point to point, a restlessness, a constant source of interest and fascination. In post-impressionism the attempt is being made to supply this want, to compel us namely to regard more than the fleeting impression. The closer we study such a picture, if it be successful, the more comes out of it, colors by their influence on one another become changed in hue and saturation, a curiosity develops and, subconsciously, we are compelled to continue our study with the result that we get ever other and other effects. It is kinetic, not static, art; it is a pattern of nature designed to create visuo-psychic impressions expressing an idea rather than an object, subjective rather than objective.

There is a physiological reason for this visual restlessness and before we go into the science of colors it may be well to explain what this reason is. The innermost layer of the eye, on to which images of exterior objects are focused, is specialized to react to sensation of light, thus setting up nerve impulses which are transmitted to the brain where they are interpreted. This layer of the eye is called the retina and it is

very much more sensitive at a small spot in the center than it is over the much larger outer (peripheral) portions, so that, of the image which is focused on it, it is only that part falling on the central portion which is distinctly seen. When we regard a stretch of country, for example, it is only in one part of it that the objects are seen in any detail—namely that part which is focused on the central portion of the retina—the remainder, since it falls on the outer portion, causing only a vague, indefinite impression. We may say indeed that the function of the greater part of the retina is merely to give us a general impression of the environment of the object which is being looked at; an impression, that is to say, which will enable us to judge of its relationship to other things. It tells what else there is to look at, and subconsciously we shift our gaze so that, piece by piece, the whole landscape comes to be focused on the central portion. We regard with the central portion what we know exists to be regarded on account of the duller image thrown on the rest of the retina.

Coming now to the question of color, any attempt to apply the scientific principles of color vision in making a picture must surely fail if it be not granted at the outset that it is only to a limited degree that those principles can apply. Color appreciation is as much a psychical as a physiological process, and indeed it is psychical not only with regard to the objective impression itself, but also with regard to the subjective, the associational mental process. Previous knowledge and training, experience, tradition, the association of color impressions with impressions previously received through other senses and stored away as memories, all play a part in determining the effect which a color or a pattern of opposed colors, has upon us. But even granting all this, there are many of the physiological laws of color vision which must be adhered to before we can expect to produce these effects.

In attempting to show how these laws may be employed in art it will be necessary for us to explain briefly some of the physical and physiological observations upon which they depend. The first of these is a physical one: it is the dissociation of white light into the spectral colors by means of a prism, or better, by means of a diffraction grating.[1] The spectral colors are red, orange, yellow, green, blue (indigo) and violet, the various shades of purple being entirely absent. When we look at such a spectrum we are at once struck with the fact that the colors differ from one another not only in their hue but in their brightness or luminosity, the yellow and the immediately adjacent portions being much brighter than the others. At once then we recognize two

[1] In the light decomposed by a prism some hues, such as those of red and yellow, occupy much less space than others, such as blue, although they do not correspondingly differ in wave-length. When light is decomposed by a diffraction grating (a glass plate ruled with very fine equidistant lines) the spaces occupied by the various hues are proportional to their differences in wave-lengths.

physiological properties for each spectral color, *hue and brightness.* There is, however, another property of colors as seen in nature which is absent in the spectrum, namely saturation. This refers to the degree of white light with which the color is mixed. It is more or less related to the artist's "value" which expresses the translation of the colors into gray.

The most characteristic of these properties of colors is their hue, and for the present we shall confine our attention to this. To understand what the hue is due to we must remember that rays of light exist in space as vibrations of the surrounding ether and that these vibrations occur at right angles to the line of propagation of the light rays. The rate of the vibration varies according to the hue. In other words, the light rays are made up of waves which are small and close together when the vibration is rapid, as at the violet end of the spectrum, and are large and wide apart when the vibration is slow, as at the red end. When these waves strike the retina they create impressions which differ from one another according to the wave-lengths. These differences we interpret as differences in hue. When the rays of the various spectral colors are reunited before striking the retina, the sensation which is created is that of white. This recombination of the spectral colors, which is called synthesis of colors, may in general be brought about in two ways: (1) by causing them to fuse together by means of some suitable optical device (such as a second prism, or reflecting mirrors) before they enter the eye, (2) by causing them to become superimposed upon one another on the retina in rapid succession, in which case the impression created by each color lasts for a sufficient length of time so that it becomes fused with those which succeed it. This result depends on the phenomenon of positive after-images; which can be demonstrated by momentarily regarding some brightly illuminated object and then closing the eyes, when the image continues to be seen for some time. Rapidly succeeding images therefore become fused into one composite impression. This retinal synthesis, as we may call it, is well illustrated in the impression produced by observing the spokes of a rapidly revolving wheel.

For experimental purposes it is brought about by using Maxwell's machine, which consists of circular cards painted in sectors with the various colors and which are caused to revolve around their centers by means of a motor. A spinning top may also be used for this purpose. By revolving a card painted with the seven spectral colors a sensation approaching that of white is produced,[2] by choosing various proportions of the spectral colors this white becomes tinted with all possible intermediate hues.

From these facts we might imagine that the retina contains a special

[2] It would be pure white were it possible to obtain artificial pigments that reflected none other than their own characteristic hues.

kind of sensory component for each of the seven spectral hues, that equal stimulation of all produces the sensation of white and that varying degrees of stimulation of certain of them, that of the hues which are intermediate between those of the spectrum.

Such a hypothesis could not however be of much practical value in explaining the color phenomena with which we have to deal in daily life. It had to be simplified. This was done by Thomas Young and Helmholtz, who discovered that three of the spectral hues, such as red, green and violet, or certain other triads, are sufficient, when mixed on the retina, to produce the same sensations as those which are produced by the seven spectral hues. These are known as *primary* colors; when equal quantities of each are used a sensation of white (or gray) results; when only red and green, the sensation is yellow; when green and violet, it is blue; and when violet and red, it is purple. Not only this, but the various intermediate hues can readily be obtained by altering the proportions of the primaries; thus, to produce orange a disc containing a larger proportion of red and a smaller proportion of green is used, and so on.

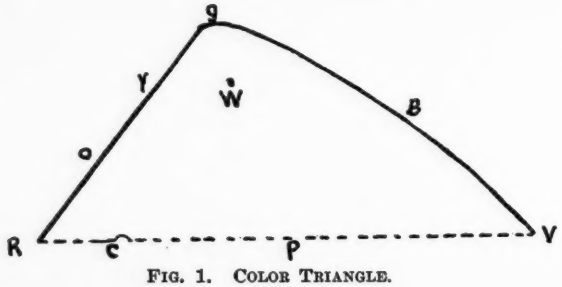


FIG. 1. COLOR TRIANGLE.

To represent these fundamental facts and hold them in mind the so-called color triangle has been constructed. At the angles of this triangle are placed the primary hues, the other spectral hues being distributed along its two sides at distances which are proportional to their wave-lengths and the purples along its base, which, since these hues are absent from the spectrum, is represented by a broken line.

But white light can be produced in still another way, namely by retinal synthesis of certain pairs of hues which on this account are called *complementary*. Thus red and greenish-blue, yellow and blue, orange and blue-violet are complementary. We may express this all-important fact by stating that for every spectral hue there is another which when mixed with it on the retina in approximately equal quantities produces the sensation of white. When other than equal proportions of complementary hues are chosen, colors are produced which are of hues intermediate between those of the complementaries and which are mixed with varying degrees of white. They are incompletely saturated colors. These facts may be satisfactorily represented by finding a point, called

W, inside the color triangle, so that any straight line passing through it will on striking the sides of the triangle join two hues which produce white. This method of finding the complementaries necessarily implies that they must be separated from one another by a considerable distance on the spectrum. For representing these facts a circle instead of a triangle may be employed, and for practical purposes, in the use of colors in painting, such a circle has been found more useful than the triangle. Before we proceed to explain its use, however, it may be well to indicate some of the applications which can be made in art of the facts we have already learned.

It is in pointilism that this application is most evident. In this method the pigments are laid down in minute areas or spots or lines so that, when the picture is viewed from a certain distance, the different hues act on the same nerve endings of the retina and therefore produce the same effect as if they had been superimposed, as by the use of Maxwell's discs. Thus, if a white surface be dotted over with red, green and violet, or any other primary colors, or with red and greenish-blue, or any other complementary colors, the surface at a certain distance will appear grayish white. If, in any of the combinations, one hue be in preponderance of the others the gray will become correspondingly tinted, so that a complete picture may be built up of areas which on close inspection are a mosaic of pure colors but appear at a distance as tinted grays.

The impressionists, Monet, Segantini, etc., appear to have laid as the basis of their picture a gray at the brightness (or value) which they desired each portion of it to assume. On these surfaces they then applied color more or less pointilistically. The neo-impressionists, such as Seurat and Segniac, on the other hand, went a step further in that the saturation was made to depend entirely on the synthetic principle. They laid on their pigments strictly in dots on a surface which was as nearly pure white as possible. Some of these neo-impressionists had, however, already begun to apply certain of the principles of color apposition in masses which we shall study later. To build up a picture pointilistically must obviously greatly increase the technical difficulties of the artist, especially with regard to outline and form; his freedom of expression is also seriously curtailed. It becomes necessary therefore that very great advantages should be the outcome of such labor. Among the advantages are the sense of atmosphere, the vibrating, scintillating quality of the color areas and the very satisfactory transitions at the edges between them, all of which are qualities that can be rendered in no way so satisfactory as by pointilism.

There can be little doubt that a great part of the peculiar impression produced by pointilism depends upon the slight movements which the eyeballs are constantly undergoing, even during our most intent fixation. This of course produces a certain amount of overlapping of the colors

on the retina just as when they are superimposed by means of Maxwell's machine. In the same way vibrations of the eyelids by moving the eyelashes across the palpebral cleft assist the synthesis, this being made evident by half closing the eyes, a method often used in studying pictures.

The success with which the desired impression can be created in a pointilistic picture often depends upon the purity of the colored dots, its vibrating quality being at the same time much enhanced by leaving a narrow margin of white around each dot. When this is successfully done there comes into play another physiological process known as *flicker,* which can be experimentally produced by rotating discs with black and white sectors at a speed which is just insufficient to cause a uniform gray. The resulting flicker possesses a glittering quality which makes it appear of distinctly greater brightness than the gray which results from complete synthesis. The same thing may be seen by observing the spokes of a wheel revolving at different velocities. Instead of black and white the sectors may be composed of different hues.

In the flicker experiments the gray remains of the same degree of saturation at whatever rate the disc is revolving, provided it is revolving more quickly than is necessary to produce complete fusion, and so in pointilistic painting, when the picture is viewed beyond the distance at which fusion occurs the impression is practically that of the older painting. It must be viewed at a distance just short of that which is necessary to produce complete synthesis. The post-impressionists such as Cezanne, Matisse, etc., realizing this limitation in pointilism, have been searching after a method by which the color scheme maintains its effect on us at whatever distance the picture is viewed. The physiological principle upon which this depends is that known as *contrast,* and this we will now proceed to study. Being a property exhibited most strikingly in the case of complementary hues, it becomes necessary for us to have, besides the color triangle, some simple experimental methods by which the complementary hues may be determined. Such methods include the experiments of simultaneous and successive contrast, in connection with which many facts of fundamental importance in the use of pigments are brought to light.

Simultaneous contrast is illustrated by regarding a strip of gray against a colored field when the gray becomes tinted with the complementary hue. There are two simple methods for performing this experiment, one is to spin a colored disc, midway between the center and circumference of which is a circle, composed partly of black and partly of white; this synthesizes to a gray which becomes tinted with the complementary hue of the colored field. The other way is to lay a narrow strip of gray paper (cut as a zigzag) on a colored sheet and then to cover the whole with thin tissue paper; the gray will assume the complementary hue. No experiments in color vision are more striking than

these, nor are there any that have more direct application in the use of colors in picture painting; thus, a gray wall viewed against a sun-lit background of green is no gray, but like the piece of paper in our experiment it becomes tinted of a purplish hue. Similarly, a shadow cast on yellow sand is blue and one thrown on the skin when this is otherwise in strong light often acquires a striking quality of green.

The phenomenon of *successive contrast* is elicited by steadily regarding a patch of a certain color for some time and then either closing the eyes, or better still, directing the gaze to a neutral surface, such as a gray untinted wall. A vivid color impression of the same shape as that of the colored patch previously looked at will be seen in both cases, but exhibiting a hue which is complementary to that of the patch.

In the experiments above described the complementary color is demonstrated by the use of a gray surface. It is evident, however, that, if we cause it to be projected against a background which itself possesses a certain hue, the two hues (the complementary and that of the regarded surface) will become blended and will have the same effect as if they had been spun on a Maxwell's disc. For example, suppose we regard for some time a blue surface and then direct the gaze to one of red, the impression will be that of orange, because the complementary of blue, being yellow, fuses with red and produces orange.

Having determined the complementaries by means of these contrast methods we may confirm our results by color synthesis; thus supposing we have determined by the contrast methods that the complementary for a certain yellow is a certain blue, we may proceed to ascertain whether this is strictly the case by preparing discs composed of these two hues and rotating them on Maxwell's machine. If the hues are complementary the greatest possible degree of whiteness will be produced.

Successive contrast finds only a limited application in art, although it is of course conceivable that the intensive fixation of one colored area in a painting, or a design, might, by successive contrast, greatly modify the colored impression created by shifting the eyes to another part. It is improbable, however, that any artist, either intentionally or unintentionally, has laid on his pigments with this object in view. Nevertheless, successive contrast may assist us greatly in the actual determination of the complementary hue. Thus, to take again our example of the gray wall against the green background, we may exaggerate the effect of the green on the gray by regarding the green for some time and then shifting the gaze to the wall, when its purplish hue will be found to be much intensified. On the other hand, simultaneous contrast is of paramount importance in art; indeed it is as important in the final impression produced by a painting or a design as any other quality which this may possess. This importance depends on the fact that when two colored surfaces are placed in apposition each becomes changed as if it were mixed to a certain extent with the complementary hue of the other; or

if a gray or a tint of low saturation (see p. 460) is apposed against a saturated color field it will assume a complementary hue of greater or less saturation according to the relative area of brightness of the apposing areas. By applying these principles in picture painting unsaturated hues may be caused to assume much greater degrees of saturation while, if the apposition be false, hues in themselves of almost complete saturation may become dull and subdued.

To the artist it comes to be of the highest importance that he possess some easily remembered scheme by which he can predict these contrast effects. The color triangle may be thus employed, but a simpler, though perhaps less scientific device, for the same purpose is the chromatic circle of Rood. To construct such a circle we must know the wave-lengths of the various colors which we desire to contrast.[3] The differences in wave-lengths are then calculated so as to correspond to angular differences, these angles being formed by the radii of the circle. As in the color triangle, opposite radii will join complementary colors and the center will represent white light, *i. e.*, the nearer the center the less will be the saturation of the color.

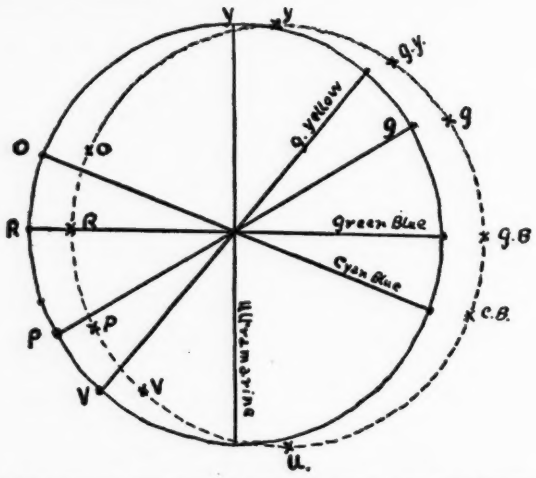


FIG. 2. ROOD'S CHROMATIC CIRCLES AS USED TO SHOW THE INFLUENCE OF ONE COLOR ON THE OTHERS.

If one such circle, drawn on transparent paper, be superimposed on another, the effect which is produced by contrasting two colors can be readily ascertained. Thus, suppose we desire to determine the influence which red has when contrasted with the other colors. Having accurately superimposed the two circles we move the transparent one so that the point on it which corresponds to red is displaced along the line joining red and its complementary, blue-green. The colors on the upper circle will now stand in positions on the lower corresponding to the

[3] This can be done by comparing the colors with those of a highly magnified spectrum of white light alongside of which is a scale of wave-lengths.

changes in hue and saturation which they would have suffered by contrast with red. Thus orange will stand nearer the center and somewhat nearer yellow, whereas green-blue will merely be removed farther from the center, which means that orange will become less saturated and yellower, whereas green-blue will increase in saturation but be unaltered in hue.

In general we may say that the effect produced by contrasting two colors is to move them farther apart on the chromatic circle, thus causing mainly a change in hue in the case of colors that stand near one another, but making a change in saturation in those which are far apart.

In order that the contrast effects may be taken full advantage of, certain conditions must be fulfilled. The most important of these are as follows: (1) The complementary tint which gray assumes is most vivid when it is somewhat darker (*i. e.,* of less brightness, see p. 460) than the hue against which it is apposed, in the case of the warm colors (the reds, oranges and yellows), and when it is lighter in the case of the cold colors (the greens and blues). The dividing line between the warm and cold colors may be taken as that joining the complementaries, yellow-green and violet. (2) When a color of low saturation (*i. e.,* nearly a gray) is apposed to one of high saturation and of complementary hue, the former will become more saturated, and conversely, if two colors which are identical in hue but of unequal saturation be apposed, the paler one may appear gray. When they are not complementary, the hue which undergoes the greater change is that which is the paler. (3) The greatest effects are produced when the color field, whose hue it is desired to alter, is much smaller in extent than that of its complementary and when it is completely surrounded by the latter. By placing a thick black line between the areas the complementary effects may be suppressed. Thus, the complementary hue which a piece of gray paper placed on a colored field assumes when it is viewed through tissue paper becomes much less evident if a thick black line be drawn on the tissue paper at the edge of the gray. When the color areas are large it is at the edge only that the complementary influence is noticeable. On the other hand when a colored area is very small it undergoes no complementary change, but merely blends with the neighboring color. (4) To obtain full advantage of color apposition the colored patterns should be very simple and of similar texture and their surfaces should be broken up by detail to the least possible degree. (5) The most marked complementary effects are obtained when the opposing hues are of equal brightness.

When we attempt to employ the chromatic circle for another purpose, namely for determining what will be pleasing and what displeasing color combinations, we find that its use is somewhat limited. This is because a psychological influence enters into our judgment in such cases.

In general however it may be taken as a working hypothesis that good combinations are always more than 80°–90° apart on the circle, that is, they should be separated from one another by about one quarter of the circumference. Even complementaries may form displeasing combinations (*i. e.*, certain reds and greens), in which case, as Rood has pointed out, the hues are usually far removed from the line which separates those that are cold and warm. When we are compelled to appose hues having a hurtful influence on one another, the unpleasing impression which they create may be lessened by certain tricks, such as by assigning one of the hues to a much smaller field, or by decreasing the saturation of one of them, or by adding a third hue whose position on the chromatic circle is as far as possible removed from the others: thus the disagreeable effect of a yellowish-green and yellow is much improved by the addition of some violet, etc.

So far, for simplicity sake, we have regarded but one quality of a color, its hue, although in doing this it has been impossible entirely to neglect the closely related qualities of *brightness and saturation.* These we shall now proceed to consider.

Brightness is most marked, under ordinary conditions of illumination, around the yellow portions of the spectrum. It is a property which is exhibited in marked degree by different grays. Indeed it is measured by finding a gray which appears of equal brightness to that of a given color. Such measurements may be made with considerable accuracy by finding a gray background against which the color becomes indistinguishable when viewed by the very outermost portions of the retina which are color blind, that is, which see no hue in a color but only a grayness, the degree of which is proportional to the brightness of the color.[4] To make such comparisons, the person must regard a dot in the center of a plain black surface and must then gradually move a small piece of colored or of gray paper, mounted on a suitable handle, from the periphery towards the center of the surface. At a certain position the colored paper will be seen as gray because the rays of light from it are striking the color-blind areas of the retina. Various grays are used until one is found which matches exactly with that created by the colored paper. A still simpler method consists in rotating the color on a Maxwell disc along with a synthetic gray. In this case judgment of equality may however be somewhat confused, on account of the gray assuming the complementary hue.

Brightness plays a most important part in the phenomenon of con-

[4] The power to judge hue depends on the presence in the retina of peculiar nerve endings called cones. These are absent from the peripheral portions and only gradually make their appearance towards the center. There is, therefore, a region between the periphery and the center of the retina which is partly color blind, blue and yellow being perceptible, but red and green still appearing as gray.

trast, for not only is the simultaneous contrast of hues obtained most strikingly when these are of equal brightness, but we constantly experience brightness contrast itself. Thus pieces of the same gray paper placed on gray backgrounds of varying degrees of brightness do not look at all alike. It is particularly at the border between the two grays that contrast brightness is most evident. This subserves the function of creating a sharp border between the grays, and it can be demonstrated by causing strips of different gray papers to overlap one another like the tiles of a roof or, still more strikingly, by rotating a disc on which when spun appear three circles of different grays, each synthesized from black and white. In both experiments the grays, though really perfectly uniform, will appear as if shaded from their edges.

Since we measure brightness in terms of grayness, and since it is most marked at the yellow portion of the spectrum, it follows that if we desire, for successful contrast effects in picture painting, to appose yellows with blues or deep reds, we must employ some artificial means either to increase the brightness of the blues or reds or to decrease that of the yellows. This can be done by mixing the pigments with white (or black), that is to say, we may alter what the artist speaks of as the value of the color but which in so far as white is used for producing the alteration is more correctly called the saturation.

It may indeed be said that the object sought in mixing pigments with white (*i. e.*, changing their saturation) is to give the impression that their properties of brightness have been altered.[5] When it is desired to raise the brightness of a given color, we can succeed only to a limited degree by using more pigment; to obtain it further, we must, as already explained, employ the property of simultaneous contrast. These methods used by the artist to alter the brightness of his colors are however liable to have a dulling effect on the whole composition unless they are used with great care and judgment. When he is compelled to lower the saturation of one color he must be careful to apply those neighboring on it in such a manner as to give the impression that the whole of that portion of the picture is of the same brightness. This he may do, either by making his pigments of similar saturation or by assorting the size of the colored areas, so that they appear by contrast to be of similar saturation.

It is a well-known fact that our judgment of the relative brightness of colors, and to a certain extent of their hues, becomes altered when the conditions of illumination are changed. A picture viewed in broad daylight may create a very different impression from that which it produces in dull illumination. For example, its hues may be dull and muddy under the conditions of illumination that are ordinarily present in a dwelling, or even in a gallery, whereas when viewed in broad day-

[5] Brightness must be distinguished from color intensity which is purely a physical property and depends upon the amplitude of the wave-lengths.

light it may sparkle with brilliancy; or there may be very little change in the actual hues, but the portions of the picture which appeared to be of greatest brightness in broad daylight may in dull light actually shift to some other part. These changes are due to what is known as *adaptation of the retina.* The most striking illustration of this is furnished by observing the colors of a flower-border after sundown. Let us suppose that the border contains geraniums (scarlet), lobelia (blue), and coreopsis (orange). As darkness approaches it will be noticed that the red geraniums become duller and duller until at last they turn black; that the orange coreopsis also becomes more neutral, but that the blue lobelia maintains the same color qualities as it possessed in daylight. The most remarkable change of all occurs, however, not in the hues but in the relative brightness of the colors, for it will be noticed that the sensation of greatest brightness has gradually shifted from the reds and yellows to the blues and greens, so that the foliage and the lobelia may actually come to appear brighter than the coreopsis and the geraniums. It is needless to point out how important an appreciation of these adaptations must be to the artist, how careful he must be to paint his picture in the degree of illumination in which he expects it to be viewed. The physiological explanation of this adaptation is that the outer portions of the retina assume a much greater degree of sensitiveness in dull light, indeed they come to be more sensitive than the central portion itself. This curious change explains why without directly looking at it we may be conscious of the presence of a small light in the darkness—a star for example—which however disappears when we direct our gaze to it. The ability of the thus sensitized outer portions of the retina to judge colors differs from that of the central portion.

When we come to apply many of the principles of chromatics in art, we are met with difficulties which at first sight may appear to be insurmountable. In most instances, however, this is by no means the case, and we shall now endeavor to show how certain of these difficulties can be explained. First of all, with regard to the mixing of pigments as compared with the mixing of colored lights, of course the two processes yield very different results: for example, mixing yellow and blue lights, as we have seen, produces almost pure white, whereas mixing these colors as pigments, as every artist knows, produces green. The entire want of similarity in the results which follow the mixing of colors by the two methods has had the effect of making some artists conclude that the laws of chromatics are useless as guides in the practical use of pigments. But this is wrong, the apparent difference being really due to a very simple cause, namely to the fact that by mixing pigment we subtract color rays from entering the eye, whereas we add such rays when we mix colored lights. To make this clear let us return to our example of blue and yellow. When we use these as pigments, we must remember

that the pigment particles have a certain degree of transparency so that light partly penetrates them, certain rays being then reflected and certain absorbed according to the hue. A blue pigment, for example, absorbs all constituent rays of white light except the blue and the hues which border on blue in the spectrum, it being impossible to procure pigments which are so pure that they do not let some other hues besides their own characteristic one pass through them. Similarly with yellow, it absorbs all the spectral rays save the yellow, the orange, and the green. Adding these two pigments together, we get every spectral ray absorbed except green, a certain amount of which both pigments have allowed to pass. In a similar way we can explain why blue and red give purple and why a mixture of all the spectral colors as pigments produces a dark gray of uncertain hue.

The above applies to a matt surface; when there is any trace of glaze there comes into play another factor which we must now consider, namely, surface reflection of some white light which has not penetrated the pigment particles at all and which therefore causes the color to be more or less unsaturated. It is by diminishing surface reflection of white light that the colors of a picture may be raised in saturation by subjecting it to alcohol vapor, which softens the medium and removes surface cracks. Reflection of white light also takes place at the surface of the pigment particles themselves and is greatly diminished when these are extremely small, hence the importance in the manufacture of pigments of thorough grinding. It is further minimized by suspending the pigments in oil, because this causes the light before it strikes the surface of the pigment particles to pass through a medium which is of approximately the same density as that of the particles themselves. This reduces the reflection, because the greater the difference of density between two media the greater the reflection of light at the interface between them.

The quickly vibrating (blue) rays of the spectrum tend to be reflected more readily than the slowly vibrating (red) rays, hence we often find that a substance is bluish by reflected light, whereas it is reddish when the light passes through it. It is indeed for this reason that during the day the sky looks blue, the light being reflected from the fine particles of dust and moisture which are constantly suspended in it, whereas after the sun has set it is red because the slanting rays come to be transmitted *through* these particles.

Artificial illumination alters the hues of pictures mainly because of mixture of colored lights, that is to say, of the hue of the light reflected from the surface of the picture and of the hue due to the particular pigments employed. Thus, if we regard a picture in yellow light (gas, carbon filament, etc.) the pale blues may appear white (mixing of complementary colors), the deeper blues assume a greenish hue, and the reds turn to orange.

In the colors which we see in nature influences of a similar kind are constantly at play, for every object, besides being illuminated by the prevailing light, has thrown on to it colors which are reflected from near by objects. In analyzing these influences there are, as Rood has pointed out, at least three factors that must be borne in mind. These are: (1) the natural or "local color" of the object, the cause for which we have already explained; (2) the colored light which is reflected unaltered from its surface, just as we have seen white light to be; (3) the portion of this colored light which is not entirely reflected but which penetrates the surface and is then reflected. Let us suppose that we are regarding a red wall of glazed brick at the edge of a grass lawn: the local brick-red of the wall will be materially altered by surface reflection not only of the white light but also of blue-green which, being approximately its complementary, tends to lower its saturation and pull it towards neutrality; at the same time, the green rays which have penetrated will on reflection assume a yellowish orange hue. The total effect is therefore that the red is somewhat removed towards neutrality and at the same time made to assume an orange hue. But it is by no means always possible to analyze these color effects, so that we must depend rather on the accuracy of the impression which we receive, at the same time bearing in mind that even objects with which we usually associate the most positive of hues may under certain conditions become entirely altered in this regard. In their use of colors, the post-impressionists are most careful to allow for these influences, although they may employ hues to produce them which at first sight appear to be entirely out of place.

Finally, we must say a few words about the relative refractability of different colors, that is to say, the ease with which the different spectral hues are brought to a focus on the retina. The rays of slow vibration, as at the red end of the spectrum, are less readily focused than those which vibrate quickly, as at the violet end. Consequently, when red rays are in focus, violet rays are overfocused and *vice versa*. The application of these principles in art depends on the fact that our judgment of distance is partly associated with the amount of effort which we must make in order to accommodate our vision. At rest the optical apparatus of the eye is accommodated for distant objects so that when these come nearer than a certain point an effort is required to make the focusing stronger. From the amount of this effort we judge in part of the distance of the object. Now it takes more effort to focus red than green or blue rays so that we always tend to locate a red object as being nearer than one that is blue or green. These facts can be very beautifully demonstrated by looking at red and green lamps placed side by side; the green light appears to be behind the red. And in picture painting the same principles can be applied, and seem to be so in many of the post-impressionists' paintings; objects are brought forward by being colored in the reds and they are pushed back by the use of blues and violets.

These facts bring us to a discussion of the influence of the blue-

violet line which so many post-impressionists are using to outline objects to which they desire, without shading, to give the impression of rotundity, or more correctly, of projection. The effect of such a line is perhaps best demonstrated in still life studies where its existence at the edges of, say, a vase, will, when the picture is viewed at such a distance that the line just disappears, cause the vase not only to stand forward from its background but also make it appear rotund, as if shaded towards the edges. The line is sometimes used in landscape pictures with the object of holding the pattern together. These effects are most marked when the object is painted in hues that are considerably removed from blue on the chromatic circle, or are of much less saturation (more removed towards neutrality). Similar effects can sometimes be obtained by the use of a black line, but none of the flaring hues can be successfully employed for making it. It is difficult to explain the action of these outlines, indeed it is almost certain that several factors play a rôle in producing the illusion which they produce. When the line is a blue one and the prevailing hue of the color field which it borders tends towards yellow a synthetic gray will result at a certain distance, thus creating the impression that some space exists between the object and its surroundings. When a black line separates two colored areas there occurs a certain amount of irradiation on to it of the neighboring hues, which therefore undergo a more or less sudden lowering of intensity at its edges, which becomes more and more pronounced towards the middle of the line until the hues finally meet and partly overlap, thus producing a certain amount of synthetic gray. This phenomenon of irradiation is well illustrated by comparing two squares of equal size, one being black on a white field and the other white on a black field; the white square looks distinctly larger than the black one. The reason is that the stimulus produced by white, mainly because of imperfect focusing, spreads on the retina somewhat beyond the margin of its image.

In this account we have not essayed to explain all of the peculiar effects which are produced by some of the most modern creations of the so-called post-impressionists. We have merely indicated some of the physiological truths of color vision upon which certain of their color illusions depend. To go further would require consideration of many optical illusions for which at present there exists no satisfactory explanation. These are not illusions of color but illusions of line, indeed many of the latest post-impressionistic pictures are produced almost entirely in black and white and the peculiar emotions which they arouse depend on metaphysical processes whose explanation we can not undertake to expound. Their aim is "to create an illusion of the fact" rather than the fact itself; to write "a visual music which shall in itself arouse the emotions."

THE PETRIFIED FOREST OF MISSISSIPPI

By Professor CALVIN S. BROWN
UNIVERSITY OF MISSISSIPPI

THE petrified forests of Arizona are well known to geologists and others interested in such things, but I am not aware that anything has yet been published on the petrified forest at Flora, Mississippi.

There are various forms of petrified woods in the state of Mississippi, but the great majority of them are silicified woods. Many of them are white or at least light-colored, and because of the color often go popularly under the name of hickory wood or hickory logs. Petrifactions which are formed in the lignite beds are often stained to a dark brown or even black shade; one and the same trunk is sometimes found partly petrified and partly lignitized. In the northeastern corner of the state there are also found samples of wood in which iron-ore is the material replacing the original woody structure. The beautiful wood jaspers, carnelians, opals and agates of Colorado, Arizona and other western states, are not ordinarily to be found in this state; though the Mississippi trees sometimes show excellent quartz crystals of small size.

Much of the Mississippi wood shows the vegetable structure almost perfectly and tends to split with the grain of the wood. Though a large

Fig. 1. Showing line of demarcation between Quaternary and Tertiary. Above this line a log is seen in its original position. Flora, Miss., June, 1912.

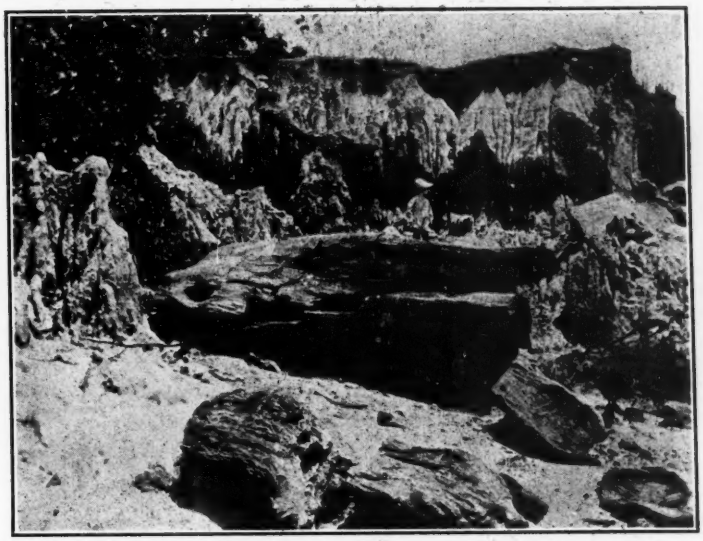


FIG. 2. A PETRIFIED LOG ABOUT SIX FEET IN DIAMETER AND TWENTY FEET LONG, SPLIT THROUGHOUT ITS LENGTH. Behind it is seen the erosion wall. Beneath the log evidences of erosion may also be seen. Flora, Miss., June, 1912.

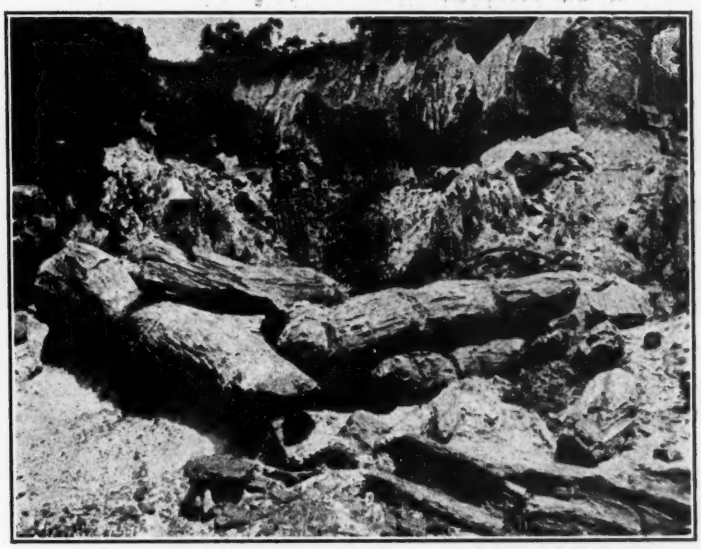


FIG. 3. PETRIFIED WOOD. Flora, Miss., June, 1912.

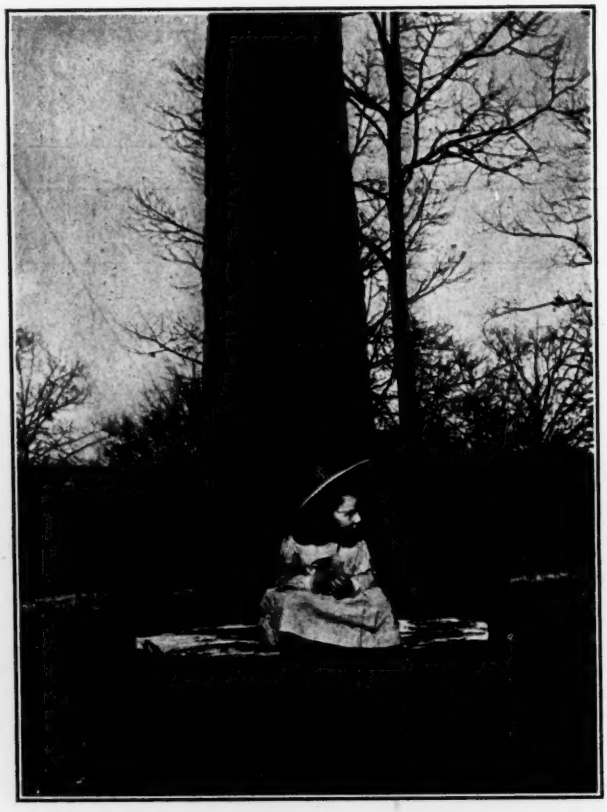


FIG. 4. PETRIFIED WOOD. University of Mississippi.

part of it is exogenous, good specimens of palm-wood are found in south Mississippi.

Most of the petrified wood in the state is found in the Lafayette formation but some is found lower down in the Wilcox and other Tertiary formations. Dr. Hilgard surmised that a great part, if not all, of the silicified wood found in the upper formation was derived ultimately from the several lignitic stages of the Tertiary.

The petrified forest, or speaking more accurately, the group of silicified logs, which I wish particularly to mention in this brief article, is found near Flora, seventeen or eighteen miles northwest of Jackson, the state capital. Here is a large field where erosion is actively taking place at the present time. Throughout the area are scattered logs and fragments in varying stages of disintegration.

An amphitheater some twenty or twenty-five feet deep and about one hundred and fifty feet in diameter, where the Columbia loam and the Lafayette sand have washed away down to the Tertiary formation, offers the best single exhibit of the logs. At the mouth of the valley the ero-

sion has extended several feet into the Tertiary. There are at least ten logs exposed in this amphitheater which vary considerably in color and composition. Some of them are almost pure white and apparently contain nearly pure silica; others are stained with more or less of foreign matter.

These logs vary in size and preservation and none of them presents the full length of the original tree. The largest observed is about six feet in diameter by twenty feet in length and is of a brown color.

FIG. 5. PETRIFIED LOG FROM PITTSBORO, MISS., now on the lawn of Dr. Calvin S. Brown at the University of Mississippi.

Another is four feet at base by about seventeen feet in length. A dark-colored log near by is five feet at base and eleven feet long. Another in a ravine to the east is four feet by twenty feet; and there are still other logs and fragments of logs scattered at various points.

Most of these logs now rest upon the Tertiary formation and therefore are slightly displaced; that is to say, the sand of the Lafayette formation has washed from beneath them and left them lying upon the Tertiary. In several places however in the vertical erosion walls logs are seen projecting from the Lafayette sand some distance above the Tertiary.

In the accompanying illustration, number four, the line of union between the Quaternary and the Tertiary is distinctly seen running horizontally through the middle of the picture. Some distance above this

line is seen projecting from the Lafayette a log in its original position. No stumps *in situ* were anywhere observed by the present writer, nor were any small branches or roots found. There are many excellently preserved knots, a beautiful example of which is seen in the picture just mentioned. So far as observed by myself, there are no other fossils in this field; but further investigation is desirable.

It is evident that disintegration is going on very rapidly in this silicified wood. The difference in the appearance of several logs was clearly noticeable after an interval of fourteen months which elapsed between two visits to the Flora forest. The principal agent in disintegration seems to be freezing; rainwater penetrates the logs and by freezing splits them. A tree which has been exposed in the writer's yard but a short while (Fig. 5) shows signs of splitting, while another in the university museum is as well preserved as when Dr. Hilgard put it there over sixty years ago.

While the Mississippi forest can not be said to rival in extent or in the coloring of its petrifactions the celebrated forests of Arizona, it is nevertheless a fine illustration of an interesting phenomenon of nature.

ECONOMIC FACTORS IN EUGENICS

By WILLIAM LELAND HOLT, M.D.
FREIBURG IM BREISGAU, GERMANY

ALTHOUGH eugenics is perhaps the newest of all the sciences, it has already become one of the topics of the day. And this is well, for no science was ever founded which promises to do so much for the improvement of mankind. Sir Francis Galton defined eugenics as "the study of agencies under social control, that may improve or impair the racial qualities of future generations, either physically or mentally." Such a broad definition evidently makes eugenics include a large part of sociology.

The object of the present essay is not to review or multiply the sad facts concerning the diminishing birth rate among the better members of all civilized communities and the unrestricted propagation of the inferior and unfit. All intelligent people are familiar with these lamentable facts. In America, indeed, popular education concerning the latter evil has so far progressed that two states, viz., Indiana and California, have already passed laws which provide, under proper control, for the sterilization of confirmed rapists, criminals, idiots and imbeciles in the state institutions. The same states and also New Jersey have acts, which provide that no marriage license shall be issued when either party is imbecile, epileptic or insane. A similar act on the statute books of Michigan provides that "no person, who has been afflicted with syphilis or gonorrhea, and has not been cured of the same, shall be capable of contracting a marriage." Ex-president Roosevelt and others have also aroused Americans somewhat to the need of positive work against race suicide, and several societies have been formed to encourage marriage, and to promote all influences which tend to raise the birth rate. One western state in a fit of enthusiasm actually passed a law which put a tax on all bachelors who should not marry within a certain period of grace!

The present writer will not concern himself with these laudable endeavors in the cause of eugenics, but will rather aim to present the social conditions in a new light; namely, to show that their basic causes are chiefly economic, and hence that remedial measures, if they are to succeed, must also be chiefly economic. In order to do this I shall take up some of the leading problems of eugenics, and point out their economic factors. In making this analysis I wish to warn the reader against misunderstanding. When I mention only the economic factors

in a problem, I do not mean thereby that these factors are the only ones, not always indeed that they are the most important ones. I shall often take it for granted that the reader is familiar with the other factors of a biological or ethical nature.

I shall begin my presentation with a discussion of birth rates. The falling birth rate in all civilized countries is one of the chief anxieties of social students and statesmen. In France it has sunk so low that, in spite of the low death rate of 22, the births from 1893 to 1902 exceeded the deaths by only 1.2 per thousand annually. Even in 1850–60 France had the low birth rate of 26, and it has fallen steadily ever since, until it has now reached the figure 21, and in some departments there are three deaths for every two births. Whereas a century ago the population of France formed one quarter of that of the world's civilized powers, and she lorded it over the Germanic nations, now her population has fallen to seven per cent., and she has almost lost her place among the great powers of Europe. Between the two ten-year periods mentioned above the birth rate has also fallen in England from 33 to 30, in Italy from 38 to 35, while in Austria it has risen from 37 to 38. The birth rate has also fallen greatly in the United States in recent decades, especially in New England among the native population. Whereas at the beginning of the nineteenth century the population of the United States was doubling every 22 to 23 years, in the last 20 years it has increased only a trifle over 40 per cent., and the increase of 21 per cent. for the last decade was the smallest on record. Most striking is the stationary population of the great agricultural states of the middle west; here the increase for the whole decade was only 6 to 7 per cent., and Iowa showed an actual decrease. The three rural New England states showed a gain of but 5 per cent. Only in the sparsely settled far-western states was the increase over 50 per cent., undoubtedly due chiefly to immigration. California, for instance, increased her population in the last decade by 60 per cent., but the birth rate for recent years has hardly exceeded the low death rate of 15 by a larger margin than that in France herself. In the New England states also the death rate for 1900 among the native whites actually exceeded the birth rate by 1.5 per thousand. Here race suicide was even worse than in France. The birth rate of the foreign-born whites in New England, however, was nearly 45. This means nothing less than that the native American stock is dying out in New England, and is being replaced by foreign races from southern Europe.

Now is it merely a coincidence that the high birth rate among the native New Englanders began to fall rapidly after the years 1820–30, at the same time that large numbers of immigrants came from Europe? The late Francis A. Walker, superintendent of the census in 1870 and 1880, maintained that the great immigration during the last seventy years had undoubtedly been a direct cause of the fall in birth rate

among the native population, by means of the disastrous competition introduced. Indeed the arrival during the years from 1830 to 1840, of large numbers of Irish and German peasants who had a much lower standard of living, and so lowered the general level of wages, was nothing less than an economic disaster for our old American stock. They shrank from the inferior competition, and were naturally loth to bear children, who must compete in the labor market with these unwelcome invaders. There is overwhelming evidence that the birth rate in all countries has always been much affected by economic changes. Professor Richmond Mayo Smith, for example, says in his "Statistics and Sociology" that a sudden fall in the birth rate is the result of war or of commercial distress or of economic disaster. We have seen that the rapid immigration of European peasants about 1830 was truly an economic disaster for the native New Englanders; and there is no reason to doubt that these unfavorable economic conditions were responsible for the great fall in their birth rate. Benjamin Kidd has said in this connection: "The unwillingness of men to marry and bring up families in a state of life lower than that into which they themselves were born is one of the most powerful of known influences working to restrict the birth rate." The causal connection between this immigration into New England and the decline in the native birth rate is deduced especially from the fact that this decline appeared first and most markedly in those very states and counties into which the immigrants chiefly went.

This check in the increase of the native population was so effective that in 1850, in spite of the immigration of nearly two million persons during the preceding decade, our total population was only 0.03 per cent. more than it would have been from natural increase alone *at the former birth rate.* This check on the native increase has persisted, indeed strengthened, with the passing decades and the ever-increasing immigration of poorer and poorer stock from Europe and Asia; so that in the Report of the Industrial Commission in 1901 Mr. Walker maintained that "if there had been no immigration into this country during the past ninety years, the native element would long have filled the place the foreigners have usurped."

I shall consider the method of action of economic conditions on the birth rate during the latter half of the last century, togther with their action at the present time. But I must explain at the outset that there is this important distinction between the two periods with regard to the operation of economic forces: namely, during the former period, when modern methods of limiting families were generally unknown, economic pressure produced an involuntary reduction of the number of children by postponing the age of marriage and by preventing many marriages altogether; while during recent years, as Neo-malthusianism

becomes more and more widespread, the economic factor produces not only this unintentional diminution of births, but also *a much larger intentional* prevention of children. Mr. Charles F. Emerick has indeed sought to prove, in THE POPULAR SCIENCE MONTHLY for January, 1911, that our modern small families and low birth rates are due almost wholly to the practise of Neo-malthusianism among married couples. But it is a biological fact that women marrying at thirty or older are less fertile than those who marry younger; and the reduced number of children usually resulting from such marriages is doubtless involuntary in many cases, and partly unintentional, at least, in the rest. The reader is accordingly requested to keep in mind in the following discussion that the economic factors mentioned may reduce the birth rate in either of these two ways or in both at once. The tremendous significance of the modern knowledge and use of "preventives," in making the birth rate much more dependent upon economic conditions than formerly, is evident.

Let us now analyze these economic factors somewhat. We might place them under five heads, as follows: (1) The increased uncertainty of a livelihood among the working people; (2) the great rise in the cost of living without a corresponding rise in wages and salaries; (3) the general ambition among Americans to give their children better food, better clothing, and especially better education than they had themselves, and so to enable them to rise in the social scale; (4) the general entrance of women into all occupations and professions; (5) the demand for luxuries, especially superfluities for children.

The first factor, uncertainty of livelihood, has increased *pari passu* with the concentration of ownership of land and other means of subsistence in fewer and fewer hands and the creation of a rapidly growing proletariat. Whereas up to the year 1820 only 5 per cent. or less of our population lived in cities of 8,000 or over, and the great majority were independent farmers, in 1910 no less than 33 per cent. lived in such cities, and probably three fourths of them are dependent upon their employer for their living. Even the farmers have lost the ownership of their land, largely by mortgaging it. They are then really working for the holder of the mortgage, and only obtain for themselves in the form of net profit, after paying their interest, a wage often smaller than that of the city worker in a store or a factory. It is not necessary to quote statistics as to the great number of men unemployed, and so without a living, in the United States even in good times and without strikes. The labor-market, at least for unskilled labor, is always congested, and during commercial crises, such as that of 1907, and great strikes, hundreds of thousands of working men and women are deprived of their livelihood for considerable periods. This sad state of things makes it extremely difficult or quite impossible for

our working-men to marry young and support large families decently. They know what it means for a man with a family to lose his job and see his family starve and be evicted from their tenement; and a great many naturally refuse to subject the woman they love to the danger of such a fate, or to hang such a heavy burden about their own necks in the economic struggle. They postpone marriage until they have saved up a little capital to protect them against loss of employment; or, as often happens, they postpone marriage until it is too late, and never marry at all.

Next comes the great rise in the cost of living, which is a perennial source of complaint and perplexity to both rich and poor. This is a rather hackneyed subject, and I will not burden the reader with statistics of prices of the various food-stuffs and other necessaries; but merely make two general comparisons. The United States Bureau of Labor computes each year an "index number" from the average prices of the most important commodities, which shows most accurately the general trend of prices. Now this "index number" rose from 90.4 in 1896 to 122.4 in 1906, a rise of 35.8 per cent. Supposing the same rate of advance since 1906, and it has probably rather accelerated, average prices as shown by the index number would be 54 per cent. higher in 1912 than they were sixteen years ago in 1896, just before the Spanish war. This means that on the average $1.54 will now go no farther than a dollar did in 1896; and consequently, unless a family which received about $500 a year in 1896 now gets at least $770, it has actually become poorer, for it can really buy less commodities.

The second way of gauging the increased cost of living is by comparing reliable estimates made at different times in the same places of the yearly income absolutely necessary to support a family of two adults and three children, the "standard" or "average family." In 1902–3, for instance, a prominent official of one of the largest charities in New York City stated that about $624 a year is necessary for a family of five in that city. The New York Bureau of Labor declared in 1902 that "$520 a year is inadequate for city workmen." Robert Hunter, the well-known authority on social conditions in New York, states in "Poverty" that "while $624 a year is probably not too high for New York City in view of the excessive rents, etc.," he considers only $460 "essential to defray the expenses of an average family in the New England states, New York, Pennsylvania, Indiana, Ohio and Illinois." He wrote this in 1904. And now in 1911 the Sage Foundation of New York states: "Families having from $900 to $1,000 a year are able in general to get food enough to keep body and soul together, and clothing and shelter enough to meet the most urgent demands of decency." This was the result of an investigation among 391 families living in the New York tenements. This agrees very well

with the estimate of Professor R. C. Chapin, quoted by Professor Scott Nearing in his new book, "Wages in the United States," that "a New York family, consisting of man, wife and three children under fourteen, could maintain a normal standard at least so far as the physical man is concerned on an annual income of $900." According to these estimates, then, the cost of living rose for New York City from $624 in 1902–3 to about $900 in 1911, a rise of no less than 44 per cent. The reader will notice that this figure is still higher than the increase of 36 per cent. arrived at above by comparing the index numbers for 1896 and 1906, although the latter period is longer.

But some people deny the great social and eugenic effect of this undeniable rise in prices, because they think that it has been accompanied by a corresponding rise in wages. This is a much discussed question, and wages vary so in different parts of America, and have risen at such varying rates in different trades, that it is impossible to obtain such accurate figures here as I have given for prices and the cost of living. Inasmuch as the majority of our wage-earners are still classed as unskilled, I will take a large class of them for comparison. In 1900 the Industrial Commission reported that the 150,000 trackmen working on the railroads received wages ranging on the average from 47.5 cents a day in the south to $1.25 a day in the north. Not allowing for unemployment, these men had a yearly income of less than $150 in the south and less than $375 in the north. Nine years later the Interstate Commerce Commission reported that the 320,000 trackmen then employed on the American railroads received an average of $1.38 a day, or $414 a year. This is an increase above the average for the north of only 10 per cent. for the nine years, as compared with the rise of 44 per cent. above quoted in the cost of living in New York City from 1902 to 1911. In some few trades, to be sure, wages have risen much more, though hardly in any as much as has the cost of living; but space does not permit of detailed comparisons; a general estimate for unskilled workers at the beginning and the end of the last decade must here suffice. Robert Hunter, for example, wrote in 1904: "It is hardly to be doubted that the mass of unskilled workers in the north receive less than $460 a year," and this must include more than half of all wage-earners. And Dr. Scott Nearing in the book already mentioned estimates that half the adult males of the United States are receiving less than $500, and three quarters of them less than $600 yearly. This lower-paid half of the total male workers must correspond fairly well with Mr. Hunter's "mass of unskilled workers," except that his estimate was confined to the north, where wages are higher than in the south. To compare the two estimates, then, quite fairly, we should probably increase the later one of Dr. Nearing's, which refers to the whole country, by about 10 per cent. to express the slightly higher

wage-level in the north. We then have $460 for the wage index in 1904 and $550 for the same in 1911; and find that this means a rise in average wages of 19 per cent. in the seven years. This rate would make an increase of 24.4 per cent. for the nine years, 1902–1911, in contrast to the increase of 44 per cent. for the cost of living in New York and 36 per cent. for the rise in average prices during the decade 1896 to 1906. I see no escape from the conclusion that *the cost of living has increased since 1896 at least 50 per cent. more than wages have risen.*

This great uncompensated rise in the cost of living means nothing less than progressive impoverishment of the mass of the American people; and is of the greatest possible injury to the welfare of the nation as well as to the racial qualities of its future citizens. Here we are only concerned with its effect upon the birth rate, which it tends strongly to reduce among the superior, foresighted part of the population, who feel the responsibility of bringing children into the world, and have the knowledge and self-restraint required for limiting offspring. The paupers, however, unless prevented by the state, will continue to breed as rapidly as ever; and the generally inferior, less industrious, ambitious, and provident part of the population will also restrict their births but little. The result is, for it is actually taking place now, that the percentage of the inferior and unfit steadily increases, while that of the superior and fit *pari passu* diminishes; and, *if this process of degeneration is not checked, the nation as a whole will become unfit and will succumb,* as most nations have done in history.

Dr. A. F. Tredgold in the *Eugenics Review* for April, 1911, gave the following fact in corroboration of the differential decline in the birth rate. He found the average number of children among 43 incompetent, parasitic working families was 7.4, while that among 91 thrifty, competent working-class families was 3.7 or just one half. Mr. Sidney Webb also found that among the members of the Hearts of Oak Benefit, which is composed of healthy, thrifty artisans of a superior type in England, the birth rate had declined by 52 per cent. from 1880 to 1904, which was nearly three times the decline for all England and Wales during this period. The same writer declares that both pauperism and degeneracy have undoubtedly increased in England since 1901. We have just reviewed the incontrovertible evidence that poverty has rapidly increased in America since 1896. Have we any reason for believing that degeneracy has not likewise increased for the same reasons as in England?

In regard to the ways in which this second economic factor works to reduce the birth rate it is only necessary to say that they are nearly the same that have been mentioned above for the first factor; namely, uncertainty of a livelihood. But the second is chiefly responsible for late marriages, sterile marriages resulting from venereal disease, failure

to marry at all, and intentional prevention of children. It is the shame of the twentieth century in the richest nation of the world, that for the great majority of Americans the big, happy, old-fashioned family of six to twelve children has become a luxury, which is absolutely beyond their means.

Our third factor in reducing the birth rate was the common ambition among our working and middle class people to give their children better advantages of all sorts, to enable them to rise in the social scale. This is surely the leading motive with a great many ambitious parents for intentionally limiting themselves to two or three children. They could afford to feed, clothe and shelter four to six children and send them to the public schools, but they could not give the boys a college education and a start in business or a profession, and send the girls to college or a finishing school, and also enable them to come out properly. Hence they have only two children, and try to give them all these social advantages. This motive for limiting births is probably the chief reason why immigrant families in the United States usually show a markedly lower birth rate in the second and third generations. In the old country escape from the working class was never dreamed of; but in democratic America they soon learned that thousands of other working people, foreign-born or of foreign-born parents, had raised themselves by industry, self denial, and prudence (usually combined with luck and shrewdness) to wealth and social position. What wonder that they aspire to do likewise, and that they find prudence absolutely demands a small family?

The same desire to give their children every possible advantage to enable them to keep their social position is perhaps much more operative among the middle class as a reason for limitation of children. The fear among middle-class parents of seeing their children sink into the proletariat is probably a stronger motive than the desire of the working-class parents to see their children rise out of it. Witness the fact that the birth rate among the professional class is only one half that of the industrial class.

We come now to the fourth economic factor in the birth rate: the entrance of women into all sorts of trades and professions, in short the whole modern woman's movement. This is extremely interesting in its relation to eugenics. Let us first consider the effect of the higher education of women. I can find no statistics to prove it, but most authorities, including Dr. J. W. Ballantyne, seem to agree that college women not only marry later, as a rule, but have smaller chances of marrying at all than their less educated sisters. Dr. Ballantyne has also pointed out that the higher education of women in America has had a distinct influence in diminishing the birth rate, and that the college-trained girl has certainly not been the mother of many children. As I have already stated, late marriages are always less fertile on the average

than early ones. But these college women, who marry late, not only have fewer children, but they also fail to bear the best children of which they were capable. For English students of eugenics have proved by extensive investigations that, when a woman bears her first child at about 25, and continues to bear at intervals of two years, the quality of the children usually improves up to the fifth or sixth, which is accordingly the best that she is capable of. But, if she bears her first-born at the age of 30 or more, all the children are usually inferior to what they might have been. It would actually seem as though nature, like a human artist, needed practise, before producing her best creations; and that women, who bear only two or three children, never give nature a chance to do her very best, but are content with her first attempts. It is evident that *all who have the cause of eugenics at heart must do all in their power to favor early as well as fruitful marriages among the better part of the population.* Sir Francis Galton laid emphasis upon this.

It should be mentioned in this connection that too close application to intellectual pursuits often causes neurasthenia and menstrual troubles in young women, which may contribute to sterility later or prevent marriage on account of poor health. Excessive indulgence in sports also frequently injures the nervous and reproductive systems.

Let us now consider the larger question of the effect upon number and quality of offspring produced by woman-labor. Here a few statistics will be necessary. In 1900, out of 23½ million women over sixteen years of age in the United States nearly five million, or about 21 per cent., were employed. Of these five million 44.5 per cent. were under twenty-five. The number of women at work had more than doubled since 1880. Women were represented in all but nine of the 303 occupations listed. In 1910, Dr. Nearing informs us, 60 per cent. of all the women-workers in the United States received less than $325 a year. Now most of these women are employed solely or chiefly because they were able and willing to work for lower wages than men; so it is fair to say that they have underbid the men, and either displaced them or forced them to accept the same wretched pay. As a result, there are "textile towns" in New England, where the vast majority of the operatives are women and children, and the men stay at home and take care of the babies! Moreover, in the public schools throughout the land women-teachers have an overwhelming preponderance over men. It is difficult to determine what is the principal effect upon the birth rate of woman's employment outside the home. On the one hand, the reduction of the man's wages by woman's unfair competition postpones and prevents his marrying; and, on the other hand, the young woman by means of her occupation may be able to save up something to marry on, and young couples, relying on their both continuing to earn money, may marry

earlier than they otherwise could, and perhaps have more children. In England, at any rate, the birth rate is highest in those counties where we find the largest proportion of women employed in factories; namely, in the urban, industrial counties of Nottingham, Staffordshire and Durham. Here we also find large numbers of married women, who are under age—in Durham over 23 per cent.—and the highest infant mortality. The infants born to these working girls have the highest mortality from premature birth, deficient vitality and all congenital defects; and all these working mothers have such a high death rate from all causes among their neglected children, that the increase of births, which results from this employment of young women, is wholly undesirable and results in deterioration of the population.

The last factor in my list was the increased demand for luxuries. A great many young men of marriageable age in the business and professional classes postpone marriage year after year, and perhaps renounce it altogether, because of the false idea that they must provide a wife with a six-room house, two servants, cut glass, fine furniture, fine clothes, and all the other luxuries which she or her richer friends enjoy. In short he "must have at least five thousand a year." The same selfish refusal to give up any unnecessary creature comforts after marriage makes many women stifle their maternal instinct and spend their substance on automobiles instead of on children. Mr. Roosevelt's well-known sermons against race suicide as a selfish, unpatriotic shirking by modern women of their highest duty to the state indeed applies with fairness only to wealthy women, who deliberately barter their unborn children for luxury and freedom from maternal suffering and cares; but these rich women and their husbands, who are equally to blame, well deserve our ex-president's stern reproofs. In this modern growth of luxury the most dangerous feature from the eugenic point of view is the superfluity of things demanded for children by middle-class parents "in order to keep up with the procession," as the phrase is. This "keeping up with the procession" has an interesting sociological basis, which deserves mention here.

The phrase really means the attempt to equal one's neighbors and business acquaintances in all the externals of life, particularly in dress, in order to maintain or better one's social position. And the economic basis of this well-nigh universal endeavor to dress better than one can afford is the class struggle. The upper classes always feel that they must show their superiority by dressing more expensively or in some new style; while the lower classes as continually attempt to obliterate this class distinction by imitating their dress and manners.

The following quotation from a recent article in the Los Angeles *Times* shows what the modern standard of expenditure for boys and girls is in the middle class.

Girls cost three times as much as boys. The girl of twenty years ago was content with one party dress and a "good" hat. Calico dresses made on the family sewing-machine were good enough for ordinary wear. The first cause of the girl's higher cost is naturally clothes. *She must dress as the others dress.* The second cause is entertainment. The college girls try to outdo one another in costly luncheons. Only families in good circumstances can afford to send their children to college for the full four-year course. The cost of sending the girl to college can be figured thus: first year, $1,250; second and third years, $900 each; fourth year, $1,000 and $200 extra for traveling during vacations; total, $4,250. The boy's expenses, on the other hand, will be $700 per year with $100 for vacations, a total of $2,900. What is the cause of this phase of the high cost of living? The setting of costly standards by the rich, which the poor, the well-to-do and the near-rich try to imitate.

It is evident that if a family demands these luxurious standards for their children, they can hardly obtain them for more than two children even with five thousand a year. It would seem that "the simple life," which Pastor Wagner came from France to teach us a decade ago, has not yet been entered upon by any of us who have the means to live otherwise. Even the poor avoid simplicity as much as possible, witness the elaborate shirt-waists and "picture-hats" often worn by working-girls and the great sums spent on liquor and cigars by working men.

So much for the economic factors in the birth rate. Let us now consider the closely related subject of infant mortality. It is now generally agreed that the best single antidote to this national evil is breast-feeding for nine full months, or as long as possible, and that in this respect the poor infant fares better on the average than the well-to-do. In spite of this advantage, however, the infant death rate is much higher among the poor than among the wealthy. Dr. Fischer, of New York, for example, found that of 500 very poor women in that city 90 per cent. nursed their children over nine months, while of 500 prosperous mothers only 17 per cent. nursed for the same period. When we learn, however, that 154 of these rich infants were supplied with wet-nurses, we see that, after all, 48 per cent. of them were breast-fed.

German investigations do not show such a striking difference between the percentages nursed by poor and by rich mothers; and the figures quoted by Dr. Fischer are undoubtedly too low for the American middle-class and probably also too high for the average working-class. A doctor, who has delivered 300 women in a country town in California, informs me that only six of them failed to nurse. We must turn to Germany for reliable statistics on nursing in different economic classes. In the city of Barmen (population 150,000) in 1905 the following percentages of infants were being nursed in the four different classes, into which the parents were divided according to income:

I	II	III	IV
Income under $375	$375 to $750	$750 to $1,500	Income over $1,500
Nursed: 80.9 per cent.	68.7 per cent.	45.2 per cent.	47.3 per cent.

It is noteworthy that the percentage nursed is slightly higher for the richest class than for class III., which corresponds to our middle class. Indeed poverty prevents a great many women from nursing successfully. It does this in two ways: (1) By depriving them of sufficient and suitable food, rest and general care, which causes their milk to fail in both quality and amount; (2) by forcing them to go out to work and give over their infants to foster mothers and cease entirely to nurse them. No doubt, however, many mothers are directly induced by poverty to nurse, because it seems to be the cheapest way. Indeed authors vary greatly in the importance they attribute to these two factors in preventing women from nursing. Dr. Spaether, for example, found that among the poor women visiting his clinic in Munich the necessity to earn money was the cause of not nursing in 20 per cent. of the married women and 52 per cent of the unmarried, while in 15 per cent. and 60 per cent., respectively, it was the cause of premature weaning. Dr. Keller found that, among 1,300 poor mothers in Vienna in 1908, two hundred and seventy-eight had not nursed at all; and, of these, 94 declared it was because they had to go out to work. Investigation revealed the fact, however, that sixty of them had received maternity insurance for four weeks, and hence were not really prevented by poverty from nursing during this period, at least. Their excuse was that it did not seem worth while to them to nurse an infant for such a short time, after which they must wean it, and have much distress in doing so.

What is the statistical effect of the employment of women in factories upon infant mortality? Dr. G. Newman in his excellent book on "Infant Mortality" shows that the death rate in England is higher in the manufacturing towns than elsewhere, and is highest in those places where the highest percentage of women of child-bearing age are employed in factories. Thus the average infant mortality for 1896 to 1905 among eight "textile towns," where on the average 43 per cent. of married women below the age of 35 were employed, was 182 per thousand; whereas the average rate among eight "non-textile" towns, where only 3.1 per cent. of this class of women were employed, was 150, that is, over one sixth less. The average infant death rate for all England then was 152. It hardly needs to be pointed out that the employment of mothers in factories in nearly all cases robs the infants of their mothers' milk and mothers' care, which results in their being improperly fed and often badly neglected, so that they either die or survive as the degenerate population, of which these mill-towns largely consist. This deplorable state of things, this persistent crime against humanity, is a necessary result of our heartless economic system, which gives these infants' fathers such a small proportion of the wealth they produce, that their mothers are forced to tear themselves away from their babes-

in-arms and let themselves also be exploited in the factory, so as to keep the wolf from the door. Does any society that is callous to such waste of human life deserve to be called civilized? Is this heartless and protracted starvation of infants by depriving them of their natural food much more worthy of a civilized and so-called Christian nation than was the deliberate exposure of infants to a more merciful death by the ancients? The United States is, alas! no less guilty of such undesigned "slaughter of the innocents" than Europe, possibly even more so, for we do not even provide our women factory workers with a month's maternity insurance, as is done by Austria, Germany and Spain.

I have no space in the present paper to consider the economic factors of other racial problems; much less to point out in detail what economic changes I think would aid most in "improving the racial qualities of future generations." I can not conclude, however, without stating my conviction that the most thorough-going economic measures are urgently demanded, and at the earliest possible moment, before the rapid degeneration of our people shall have brought us to the danger point.

Sir Francis Galton must have foreseen the need of economic reform when he said: "The economic burden of raising a family is such as to discourage many, whose qualities should be continued to other generations, *and there can be no doubt that it would pay society to furnish ample means for the industry of child raising to those who are especially fitted to engage in it.*" The philanthropy of even our American millionaires would be hopelessly inadequate to furnish "ample means" to a quarter of the American families, "who are especially fitted to engage in child raising." Only the state, that is the nation, could foster practical eugenics on such a grand scale. There is no doubt whatever that state support of mothers and children would solve the race-suicide problem, and I see no reason to hope that anything else will. As an editorial in THE POPULAR SCIENCE MONTHLY recently said, "Children are no longer a financial asset to their parents, but they are this to the state and to the world; the state must ultimately pay for their birth and rearing." It is absurd to fear over population in America for centuries to come, since, as Professor Herbert Miller has ably shown in the same journal for December, 1911, the law of diminishing returns is obsolete and "the resources of production show no more signs of exhaustion than the heat of the sun." Finally, as soon as public opinion has been educated sufficiently to appreciate the justice as well as the desirability of such legislation, there seems to be no reason why an intelligent cooperative commonwealth could not or would not prevent the conspicuously unfit from marrying or reproducing at all, discourage the relatively unfit, and encourage the fit, in every way consistent with humanity.

Don't you go to dinner with me please? Sure.

HOW THE PROBLEMS OF THE RURAL SCHOOLS ARE BEING MET

By MARY A. GRUPE

WASHINGTON STATE NORMAL SCHOOL, ELLENSBURG.

THE little red schoolhouse is all well enough as a matter of tradition and history. It has served its purpose and no amount of sentiment for its past achievements can make it a thing acceptable to the present generation. Time was when the one-room school house was quite as well built and furnished as the dwellings from which the children came, but that is past and there is no gainsaying that the one-room district school is generally unsightly, illy ventilated and meagerly equipped. Moreover, the few children, many classes, formal bookish instruction, and inadequately trained teachers make it altogether unsatisfactory. However, a habit dies hard even though through evolution the use for that habit has disappeared. No doubt the one-room district school was and still is a necessity in some isolated and inaccessible localities, but because it got fixed as a system it still maintains where conditions no longer warrant, and where it positively saps vitality without bringing adequate returns. This ancestral school, once performing an important function in New England, still persists there, although, because of migrations to centers of population, it has practically lost its use. The district system, thus originating in New England, was naturally, but unfortunately carried west and all over the United States became the prevailing type.

Heartless as it may seem to say so, the outlook for any radical improvement of the one-room school, especially under the district system, appears hopeless. Poor as it is, the cost per pupil is greater than that for the best city schools. The Michigan report for 1902 shows that for schools averaging fewer than six, the cost per pupil was $99.50 each year, schools of fewer than fifteen paid $41.60, while the city average was $19.50. This condition is wide spread. The district system is to a large degree responsible for the weaknesses of the rural schools. To secure the building and equipment necessary for efficient work would make the tax upon the people of such a small area as a district too burdensome. The isolation and hampering conditions make it almost impossible to secure well-trained teachers. Kansas tried to attract better teachers by raising the salaries, but failed, for the discomfort and inconvenience they must undergo of living in unheated rooms, of being forced to sit with the families to study in the evening, and of having no con-

genial companions, were not recompensed thereby. Moreover, the large number of classes and subjects imposed upon one teacher will always forestall any attempts to make the work equal to that of the city schools, or to introduce a course of study especially adapted to the needs of the country. Expert supervision can not be supplied because the many schools, long distances apart, make the attendant expense prohibitive.

In refutation of the above hopeless outlook for any improvement of the one-room district school the optimist points proudly to one here and there, modern in every respect, as an example of what may be accomplished anywhere. However, he forgets that these few schools were made excellent through incidental or local enthusiasm and support. He forgets, or he does not know, that there are thousands of one-teacher schools which can not be so reached. For example, in 1907 Texas had 2,668 one-teacher schools, in 1909 Kansas had 7,756, and Nebraska over 4,000. Mississippi reports 75 per cent of her schools to be of this type at the present time.

Unconsciously a solution of the difficulty began early in Massachusetts along the lines that are being consciously pushed to-day. Parents began sending their children from their own districts to larger and better schools. This led to the abandonment of some and the joining of other districts in order to have good schools nearer home. But natural evolution proved too slow a process, so we find as early as 1869 that the legislature enacted a law empowering a town to raise money by taxation for the transportation of children to larger schools. Thus consolidation for the betterment of rural schools began. Later the state passed a law extending the minimum length of the school year to thirty-two weeks, a measure which materially helped to close small schools and to promote the growth of larger ones. At the present time consolidated schools are found in nearly every county of the state. By 1897 all the New England states had adopted laws similar to those of Massachusetts.

Since that time some form of consolidation has been tried in about thirty-four states. A 1910 bulletin, by G. W. Knorr, special field agent for the Bureau of Statistics, states that 95 per cent of the school patrons trying consolidation are enthusiastic in its praises and not one abandonment of a completely consolidated school was found among those investigated. It is as successful in Idaho, Vermont or Florida as in the prairie states of Indiana and Illinois. Superintendents of states where consolidation has not been tried express themselves as believing that it ought to be adopted. The large number of official bulletins on rural schools attest to betterment along the following lines: building and equipment, grading and course of study, length of term, attendance, interest on the part of pupils and patrons, teachers, salaries, supervision and administration. The growth of the local high school and larger high school attendance is marked. The advantage which ought to make

its appeal to the practical man is that there is a far more adequate return for the money invested.

The greatest drawbacks to the furtherance of consolidation are the reluctance of communities to give up their district schools and to substitute a new order of things, and the lack of legislation to permit and encourage it. The few real difficulties, such as bad roads, great distances to be traveled, long hours away from home, and cold lunches, which have been urged against consolidation, are also met with by those who attend district schools, and are on the contrary partially solved by transportation. In Indiana improvement of roads is following fast in the wake of the consolidation movement. The installation of domestic science enables the schools to furnish warm lunches. Those who make the complaint that expenditure is increased overlook the fact that the man who sends his children out of the district to a better school pays twice for their education, taxes in his own district and tuition in another, and the man who patronizes his own one-room school sometimes spends four times as much as the city man while receiving a poorer return for his money. The cost per pupil in a consolidated school is often the same or more than in one of the larger one-teacher districts; however, it is not cheapness that should be sought. The cost certainly should not be exorbitant, but it should be adequate to secure the best educational advantages. A recent study by Professor J. F. Bobbitt mentions the following objections which are being made to consolidated schools: attendance is not radically bettered, scholarship is not improved, and cheapness is not secured. Professor Bobbitt replies that while his statistical study shows there is not a great difference in attendance during the first five years, the attendance is much better in the upper grades. He also says that those who argue that scholarship is not strengthened base their opinion upon the results of formal examinations, utterly ignoring the fact that children in the consolidated schools have a broader curriculum, more individual attention from teachers and better social and sanitary conditions, all of which can not be measured by the traditional word examination.

On the whole it seems that consolidation has been tried long enough and in a sufficient number of geographically different localities to raise it above the experimental stage and to prove it a solution for some of the ills from which the country schools are suffering.

The student of the rural problem is next confronted by the question of means that have been found effective in furthering consolidation and in making consolidated schools more efficient. Those states possessing laws of a prohibitive, persuasive or constructive type have a basis of procedure the lack of which has prevented progress in other states.

From nearly every state superintendent to whom Professor D. D. Hugh sent a questionnaire asking for information regarding legislative

or other means that have been found most effective in promoting consolidation, came the reply that a larger administrative unit is desirable; and the majority favor the county unit with one board of education in charge of all the schools of the county. Under such a system local district feeling is abolished. The county is districted according to topography, roads and population. In Maryland the county is made the tax unit for the collection and distribution of school money. This system is found in the south and is gaining adherents in the west. Oregon has lately made provision for the establishment of a county educational board in counties having sixty or more districts, and for a supervisor for every fifty districts in such a county. In Utah several districts may place themselves under the management of one board of education for the purpose of securing better administration and supervision. Last year New York put a law in operation which combines towns into larger administrative districts and which ought to make supervision of country schools more efficient. The township plan prevails throughout New England and the Middle West, but a number of superintendents in these states express themselves as believing that the county unit would bring even better results.

Legislation designed to promote the efficiency of schools rather than consolidation sometimes forces the latter. Probably the greatest incentive for consolidation in Indiana is the stringent law abolishing all schools where the attendance has been twelve pupils or fewer for the period of a year. Legislation fixing the minimum length of the school year is aiding consolidation in Massachusetts and in other states, as small schools can not afford to keep open for so long a period.

The earliest and most wide-spread encouragement given to consolidation through legislation was that by which transportation of pupils was paid for out of the tax fund. In Chippewa County, Wisconsin, it is estimated that transportation is 50 per cent cheaper than the cost of maintaining two separate schools. Where public conveyance is provided, the increase in enrollment and average attendance is very marked.

One of the latest forms of legislation for encouraging consolidation and improving the work of the schools is that of providing grants of money to be given to schools attaining certain standards of efficiency. Minnesota offers $1,500 yearly to rural schools of four departments maintaining teachers of certain qualifications, a library, and agricultural and industrial work. Smaller sums are given to schools of three and two departments. Aid for building is also granted to the amount of 25 per cent of the cost, provided that no building shall receive more than $1,500. In Washington a bonus of $150 is received by each consolidated school composed of two district schools. A special grant is made of $300 per year by Wisconsin to graded schools of three departments and of $200 to those of two. To schools providing for instruc-

tion in the work of agriculture, domestic science or manual training special aid is also given. A very few other states, among them Oklahoma, New Jersey and South Carolina, make some small appropriations to further consolidation. Mr. Hugh,[1] in commenting upon the above methods of encouraging better schools says:

> Many of the advance movements in education have needed to be fostered at first in some special way and why should this not be true of our rural schools? There is no good reason from the standpoint of educational efficiency why our system of prorating all the state education funds among the children is necessarily the best. A judicious use of a part of this amount to encourage laudable educational undertakings might secure much more valuable results.

In this connection the "object lesson" consolidated schools built and maintained in four provinces of Canada by Sir William McDonald merit attention. Each school was equipped for manual training, household sciences, nature study and school gardening, and efficient teachers were provided. For a period of three years all expenses above the cost of maintaining the small schools which these larger ones supplanted were paid by Sir William. The results are encouraging. The average daily attendance was estimated to be 55 per cent higher than that of the former schools of the localities. The high school attendance increased wonderfully. After the three years were up the people took over the support of the schools. Moreover other schools were consolidated; Nova Scotia, for example, made twenty-two effective schools out of fifty-five poor ones.

Another means of bettering schools which is probably more effective than the offering of grants for attainment of certain fixed standards, is that of giving outright from the state or county fund larger amounts to the weaker districts instead of making an apportionment on a pro rata basis. Opposition is still raised to such procedures on the ground that some districts get more than they pay for, but we are fast coming to a realization that there should be equality in educational opportunity and that to strengthen the weak is of advantage to the strong as well. One of the best discussions of the rural school problems and of the appalling condition of a large number of Ohio's rural schools has recently been held by the School Improvement Federation of that state. This body in advocating equality of educational oportunity for all and is planning a campaign to secure legislation which will make the county the unit for taxation and which will create a state fund to be apportioned, not according to school attendance, but according to the needs of districts.

One of the great hindrances to progress in our rural schools is the inefficient instruction prevailing there. Statistics show that only young, untrained teachers or those who can not obtain positions elsewhere are in the main the teachers of the one-room district schools. Consolidated

[1] D. D. Hugh, "The Consolidation of Rural Schools," *Bulletin State Teachers College*, Greeley, Colo.

schools are able to attract and to hold a better teaching force, not only because of higher salaries, but because of better living and social opportunities.

However, while it is possible to secure for consolidated schools trained teachers who are able to carry out a course of study such as is found in our city schools, at the present time there is a dearth of teachers who know anything about the country schools or who have been trained for the special purpose of teaching in these schools. Normal schools fulfill but half their mission if they neglect the rural schools. They are fast waking up and endeavoring to supply the need, as is evidenced by the fact that nearly all the 1912 circulars contain offers of work in agriculture and instruction for rural teachers. Terre Haute, Macomb, Kirksville, Hays and a few other western normals have established model rural training schools. Certainly normal schools and agricultural colleges should keep in touch with country schools through systematic visitation, and this is being done in some states. When Minnesota offered grants for efficient rural school work she wisely offered bonuses to higher institutions for the establishment of departments of manual training and agriculture. Not only normal, but high schools and some fifty others come under this provision. A Minnesota educator writes that some of this work is being wretchedly done and the money wasted, but it must be borne in mind that the pedagogy of the rural school is still in its infancy and blunders are bound to be made. Wisconsin has a system of county training classes, and other states have established such classes in connection with high schools, but what should be the character of the rural school curriculum is still very problematic. At the present time there is a very strong feeling that nature study, school gardening, elementary agriculture, domestic science and manual training should be a vital part of the country school curriculum. In Europe the school garden originated with the rural school, and as early as 1814 it was to be found in Germany. Practically all northern European countries with the exception of England require school gardening or elementary agriculture to be taught in the country schools. Certainly a policy that has been pursued for so many years in industrial Europe merits attention here. In this country, on the contrary, the school garden movement developed in the city. At the present time about ten states require elementary agriculture to be taught in the rural schools, and teachers to pass examinations in the subject. These states are mostly in the south.

It would seem that the establishment of rural school libraries would have been one of the earliest and easiest steps to have been taken for the betterment of these schools, but practically little has been accomplished. New York boasts of a library for every school. Ohio has a large traveling one. Minnesota encourages the establishment of libraries by the

offer of state grants. Missouri, Maryland, North and South Carolina have either compulsory or conditional legislation on the subject.

That the consolidation movement has been responsible for an increase in the number of rural high schools is certain, but exact information is not available. In the bulletins on consolidation frequent mention is made of consolidated schools adding one or more high school years to their curriculum. It is estimated that where local high schools are maintained the attendance of pupils of high-school age is increased from 60 per cent to 70 per cent. The presence of the high school has been reactive and in many instances has stimulated the work of the grades and caused a greater number to complete the elementary course. Besides developing out of the grade schools the consolidated high school has had independent growth in many states; districts have joined for the purpose. In New England and the middle west the township is the prevailing unit; in other sections of the country the county high school is favored. Each of these plans has drawbacks and advantages so that several states have provided for the use of any one or all of them. Again we note that if the county were the administration unit the location of high schools could be put upon a more rational and economical basis. Nineteen states encourage the establishment of the support of rural high schools by direct subsidy, by free tuition, by reimbursement for free transportation, or by a combination of these methods. It is exceedingly gratifying that the country is beginning to feel that it is quite as much the right of every child to have the benefit of a high school education as to possess that of the elementary school. The course of study adopted in most of these schools does not differ from that of the city, and while there is a great deal said about the necessity of a course of study especially adapted to the country, no one has come forward with anything very practical. The Minnesota law encourages the teaching of manual training, domestic science and elementary agriculture by offering grants to schools so doing.

It is high time for an awakening in regard to the status of rural education. The gravity of the situation is emphasized if the estimate made by Mr. Foght[2] that one half the school population belongs to the rural schools and that 95 per cent never get beyond their respective districts is correct. That the rural school situation is the great problem in the educational world to-day, and that it is to receive the attention of educators at least, is evidenced in the interest manifested last year by the National Educational Association resulting in the appointment of a committee to thoroughly investigate and to recommend means of improvement, and of awakening the public to a realization of the rural school needs. What will be accomplished by this committte remains to be seen.

[2] Foght, "The American Rural School."

THE INCREASE OF AMERICAN LAND VALUES

By Dr. SCOTT NEARING

UNIVERSITY OF PENNSYLVANIA

So much has been said and written regarding the theoretical importance attaching to the rise of land values that the student of economics looks eagerly for some collection of facts which shall in a measure substantiate the numerous theories advanced. To his consternation he discovers, after a careful examination of economic literature, that little of importance has appeared on the subject. The fundamental significance of land value increases is conceded in every land, yet, with the exception of farm land values, there has apparently been no systematic attempt to discover the extent of the land value increases. Although an examination of the available facts has convinced the writer that the time is not yet ripe for an authoritative statement, the data at hand do indicate rather clearly the trend in land valuation.

Land values, in so far as they relate to the present discussion, may be conveniently grouped as follows:

1. The value of lands containing minerals and fuels.
2. The value of water rights.
3. Timber land values.
4. Farm values.
5. Urban land values.

Mineral land values and the value of water rights may be dismissed with a word. Repeated inquiries directed to state officials, to the federal authorities, to trade journals and to prominent engineers, failed to elicit any response worthy of consideration. Indeed, one of the most prominent mining engineers in the country goes so far as to write:

> I have no reliable information to give you as to the extent to which mineral land values have increased during recent years. Mineral lands become valuable only with favorable developments, and do not rise in value in conformity with laws determining values of other kinds of property.

The editor of *The Engineering and Mining Journal* (Mr. Walter R. Ingalls) writes (January 9, 1913):

> We have not compiled any data regarding the increase in the value of mineral lands, and do not, in fact, see how any such data that would be worth anything could be compiled.

The State Mining Board of Illinois, in a somewhat more optimistic mood regarding the statistical possibilities, writes (December 19, 1912):

The coal lands in certain parts of the state have increased a hundred per cent. in value for a period of ten years, while in other portions of the state the increase in value has been very slight. The values as a whole are increasing from year to year.

The Wisconsin Tax Commissioner, after a most exhaustive report, makes the following statement:[1]

Under present statutes minerals enter into the valuation of the land in which they are deposited. This law is absolutely impossible of just enforcement. The assessor can have no reliable information as to the amount of the mineral in the ground, even in operated mines, much less its value, which must depend upon the quantity and quality of the deposit, cost of mining, and other matters requiring the highest expert knowledge. In practise the consequence is that no effect is as a rule made to tax the mineral.

The net result of this rather extensive inquiry into the increase in the value of mineral lands was therefore practically *nil*.

Even less success attended the attempt to secure any reliable information regarding the value of water sites. The development of water power on a commercial basis is so recent, and the variation in the facilities afforded by different sites is so extreme, that it seems impossible to make any just estimate of the extent to which these sites are increasing in value. It seems fair, however, to state that with the exhaustion of the coal supply, on the one hand, and the improvements in electrical appliances on the other, the near future should witness a rapid advance in the commercial value of water-power facilities.

Aside from the discouragement involved in this attempt to draw statistical blood from an economic stone, the results yielded by the study of land values, though in no sense conclusive, are in every way suggestive. The federal government has recently completed an extensive investigation of the lumber industry. The Census Department and the Department of Agriculture both attempt to secure farm values, and a number of cities have instituted systems of separate assessments for land and improvements, which makes a determination of land values in those cities comparatively easy. Therefore, for timber lands, for farm lands and for city land the sources of information merit attention.

Unlike mineral and fuel deposits, timber tracts are susceptible of definite measurement and valuation. Private dealers as well as state and federal authorities were most generous in the cooperation. The information from private sources and from state officials is intended only to corroborate and supplement the excellent body of information compiled by the Bureau of Corporations.

Timber is an anti-social scapegrace. For a generation it has been the leader in the merry race of upward-moving prices. Since 1890, the prices of timber products have risen faster than the prices of any other group of commodities. The latest wholesale price-list issued by

[1] Report of the Wisconsin Tax Commission, 1910, Madison, Wis., 1911, p. 16.

the Bureau of Labor (Bulletin No. 99, March, 1912) reports for lumber products a rise in price which is little short of phenomenal. Taking as a basis the price between 1890 and 1899, the price of hemlock lumber rose (1890–1912) from 105.2 to 172.9; of hard maple, from 100 to 129.5; of white oak, from 98.6 to 154.5; of white pine, from 96.4 to 214.2; of yellow pine, from 112.4 to 177.3; of poplar, from 97.2 to 196.4; of spruce, from 113.5 to 169.2; of shingles, from 110.7 to 130.1; of tar, from 122.4 to 176.4; of turpentine, from 122.0 to 203.1; and rosin claps the climax with an increase from 96.1 to 466.5. This series of twenty-two years, therefore, shows a remarkable rise in the wholesale price of timber and timber products. One turns from this extraordinary increase in the price of timber products to inquire into the increase in the value of the lands from which timber comes. Has the rise in the value of the land from which the raw material is derived corresponded with the rise in the value of the raw material?

The inability of officials and of private persons to supply data on the increase in the value of mineral lands was more than offset by their generosity in furnishing information regarding the rise in timber values. The editor of *The Lumberman's Review,* Frederick J. Caulkins, comments (March 19, 1913):

> The sharp upward movement began about 1899, since which time I should say that timber had increased at about the same rate as lumber, namely, about one hundred per cent.

A number of private firms wrote interesting letters regarding the movement of prices in their own section. A lumberman from Au Sable, Mich., states (March 5, 1913):

> Hard-wood lands from which the pine had been cut were sold (1895) by pine operators, from one to two dollars per acre. Gradually, but steadily, these lands have advanced in value, until at this time they would bring from twenty to sixty dollars, and more, an acre.

A prominent lumber manufacturer from Bay City, Mich., writes (April 3, 1913):

> In Minnesota white pine has been sold at from eight to twenty dollars per thousand feet. In Michigan, hard woods, including hemlock, have advanced from five and ten dollars per acre to, in some instances, as high as ninety dollars per acre for especially good tracts of timber.

Another lumberman gives an excellent illustration of a small increase in values (March 24, 1913):

> Six years ago I bought a tract of hard-wood timber land in the upper peninsula of Michigan. The average cost was about nine dollars, and the interest, taxes and fire protection brought the investment up to about sixteen dollars an acre. The land could not be sold for over twenty dollars an acre to-day.

Similar letters from other sections of the country show a compara-

tively wide variation in the extent of the increase in forest lands, but a very obvious increase none the less.

Public officials were also liberal with information. The secretary of the Forest Park Reservation Committee of New Jersey gives it as his opinion that

> It is no overstatement to say that forest property in any part of New Jersey is worth at least double what it was worth ten years ago.

The acting state forester of Minnesota believes (January 3, 1913)

> that the value of wild lands in the northern part of this state has advanced rapidly in the last ten or fifteen years. I believe that it is safe to say that this increase has been as much as from one hundred to one hundred and fifty per cent.

The Conservation Committee of the State of New York writes that

> In 1890 a law was passed providing for the purchase of land for forest preservation purposes, not to exceed one dollar and a half per acre. The lumbermen that operated these lands and removed the spruce down to about twelve inches stump diameter, seemed to be anxious to sell their land at that time for this price. It has often been stated that property which the state acquired at that time for this price is worth from twenty-five to thirty dollars per acre at the present time.

Austin F. Hawes, the state forester of Vermont, believes that

> It is safe to say that land covered with good timber has doubled in value within the last fifteen years.

The state forester of Kentucky writes that

> Judging from the experience of Berea College, which owns about five thousand acres of timber land, on the average timber has more than doubled in value in the last ten years.

The State Board of Forestry of Wisconsin fully confirms the estimates made by private lumbermen from that section of the country. The state forester writes (March 4, 1913):

> I believe that the following prices are approximately accurate for the state as a whole:

	Stumpage 20 Years Ago	Stumpage To-day
White pine	$3.00	$10.00
Norway pine	1.00	8.00
Hemlock	.50	3.00
Birch	2.00	6.00
Basswood	3.00	8.00
Elm	2.00	6.00
Tamarack	.50	3.00
Cedar	1.00	3.00
Spruce	2.00	6.00

> On specific tracts of pine I know of several instances where the stumpage has increased from $2.00 to $5.00 twenty years ago, up to from $15.00 to $20.00 to-day. Another specific tract of mixed timber was appraised and offered for sale by the state for $425, in 1902, but there was no bidder at this price. This winter we have sold the timber on this tract for $1,860.

The federal government in Part I. in the Report on the Lumber Industry takes up the problem in very great detail. While recognizing the difficulty of making a definite statement regarding the extent to which the timber land has increased in value, the writers of the report are nevertheless struck by the extent of the increase.[2]

> The value of timber varies so extremely, according to location, species, quality and stand, that it is impossible to measure accurately the average amount of the advance. For the purpose of this report it is not necessary so to measure it. The comparative figures hereafter given are not intended to represent the average values of any kind of timber or to establish in any sense a timber price.
>
> That the increase has been nothing less than enormous is recognized by the men most familiar with the business. In speaking of the rise of prices in the last twenty years they refer to changes from 12½ cents to $4.00 per thousand; from 10 cents to $3.00 a thousand; from $5.00 to $20.00 an acre; 300 per cent. in ten years; from $1.50 to $20.00 an acre; from 50 cents to $3.00 per thousand. These figures are for southern pine. In cypress: from 15 cents to $5.00 a thousand. In the Lake states men in the business similarly speak of increases from "no market value" (hemlock and hardwoods) to $4.00 to $10.00 a thousand; from $2.00 to $6.00 a thousand (hardwoods). In the Pacific-Northwest similar general statements are made of rises in value, such as 15 cents to $2.50 a thousand; 10 cents to $2.50 a thousand; "no market value" to $2.50 a thousand; 75 cents to $2.50 a thousand.
>
> While these statements give no accurate measure of the general rise of stumpage values, they do show that, according to this report of lumbermen, such rise during the last twenty or thirty years has been enormous.[3]

There are obvious difficulties in the way of setting any definite limitation on the increase in the value of timber lands.

> The rise in stumpage values is likely to be greatest when a new region or a new species is just beginning to attract attention. When timber is selling by the acre at rates equivalent to ten cents a thousand, it may rise almost at once to fifty cents a thousand. The increase on each thousand feet in such a case is unimportant; yet it is an advance of four hundred per cent.[4]

Roughly, during the decade ending with 1907 or 1908 (the period immediately before the industrial depression) the federal investigation indicates that "the value of a given piece of southern pine taken at random is likely to have increased in any ratio from threefold to tenfold."[5] The investigators found instances of even greater increases. For example, tracts which sold by the acre at ten or fifteen cents a thousand feet had advanced twenty, or even thirty fold, in ten years; but in general these figures seem to hold fairly true. In the Lake region "the general ratio of advance of timber values during the last ten or twenty years has probably been less than in the south. Perhaps

[2] "The Lumber Industry, Part I., Standing Timber," Washington, Government Printing Office, 1913.

[3] *Ibid.*, p. 25.

[4] *Ibid.*, p. 214.

[5] *Ibid.*, p. 214.

the advance of any given tract, taken at random, in ten years from 1898 was most likely to be between twofold and fivefold." In the Pacific northwest, where the development in lumbering has been comparatively recent, "a tract taken at random is likely to have increased in any ratio from threefold to tenfold in the ten years ending in 1907 or 1908."[6] Here the proportion of extraordinary advances "is probably greater than in the south."

The rise in timber lands would therefore seem to have more than justified the increases in the wholesale price of lumber. Even in the older section, where the timber has been largely cut away, the increases have been rapid. In the newer section, which have recently developed as lumbering regions, the rate of increase in timber land values has been little short of stupendous.

No student can turn away from these records of the increase of timber land values since 1890 without a feeling of profound wonder. Twofold, fivefold, tenfold increases in two decades are immense, even in a developing country. That the price of timber products should have advanced rapidly in view of this tremendous increase in the value of timber land goes without saying.

Timber is in a peculiar position, economically. A hundred years ago it was an obstacle to American progress; to-day it is one of its rapidly vanishing resources. The approaching exhaustion of the timber supply undoubtedly plays a large part in causing the upward trend of prices. Not until the growing of timber is placed on a business basis and the demands of timber users are made commensurate with that business in this country, can a normal adjustment of prices be expected.

Farm land values present no such unusual difficulties as these encountered in the analysis of timber land values. Farming is an established business. The best farm land of the United States is largely under cultivation. If properly pursued, farming does not exhaust the resources of the land—rather it increases them. Hence, the increases in farm land values present an illustration of very normal land value increase.

The material dealing with the increase in farm values is by far the most accessible of all the data on land values in the United States, since the Bureau of the Census makes elaborate returns on the subject. Although these returns are open to some very obvious and often-repeated criticisms, they probably represent, on the whole, a fairly accurate statement of the increase in the value of farm lands in the districts which they cover.

The censuses of 1900 and 1910 give a separate statement of the value of land and buildings. Prior to that time land and buildings were grouped together. The last two censuses therefore furnish as

[6] *Ibid.*, p. 215.

accurate a measure as may be of the extent to which farm land, irrespective of improvements, is increasing in value.

During the decade between 1900 and 1910, the value of all farm lands in the United States increased from $13,058,000,000 to $28,476,000,000—equivalent of 118.1 per cent.[7] Not one of the nine geographical divisions covered by the census shows any decrease in farm land values. The increases, however, vary extremely. The least increase (19.1 per cent.) is shown in the Middle Atlantic States; the greatest increase (313 per cent.) is in the Mountain States. The largest total increase (slightly more than six billions of dollars) occurred in the Middle Western States, which gave a percentage increase of one hundred and fifty-eight.

A further inspection of the figures by states shows that the farm land increases are sectionally rather uniform. For example, in New England three of the states (New Hampshire, Vermont and Massachusetts) have increased between twenty and thirty per cent.; for Connecticut the increase was 37 per cent.; for Rhode Island it was 12 per cent.; and for Maine, 75 per cent. In the Middle Atlantic States, New York shows an increase of 28 per cent.; New Jersey, of 33 per cent.; and Pennsylvania, of 9 per cent. The increase for Pennsylvania is the smallest increase in agricultural land values shown by any state in the country between 1900 and 1910. The increases among the East North Central States vary from 45 per cent. (Michigan) to 104 per cent. (Illinois). In the West North Central States, however, the variation is considerably greater—from 82 per cent. (Minnesota) to 377 per cent. (South Dakota). Of the South Atlantic States, four (Delaware, Maryland, Virginia and West Virginia) show increases of less than one hundred per cent. In this same class fall Kentucky and Tennessee from the East South Central Group, and Louisiana from the West South Central Group. All of the other Southern States have increases of over one hundred per cent., and Florida (204 per cent.) and Oklahoma (334 per cent.) lead all of the others in their ratios of increase. Among the Mountain and Pacific States, only three show increases in land values of less than two hundred per cent. They were Utah (147 per cent.), Nevada (165 per cent.) and California (108 per cent.). The increase in Montana was 130 per cent.; in Idaho, 319 per cent.; in Colorado, 301 per cent.; in New Mexico, 470 per cent.; and in Washington, 421 per cent.

The total increase in the value of farm land from 1900 to 1910 for the whole United States was fifteen and a half billions of dollars, more than thirteen billions of which is credited to the territory lying west of Pennsylvania, north of the Mason and Dixon Line and west of the

[7] All of the figures in this section are taken from the abstract of the 1910 census.

Mississippi. In short, the great farm land value increases occurred in that section of the country from which most of the necessary farm products are derived. An examination of the figures in the preceding paragraph shows that of the 22 states outside of this area, none reports increases of more than two hundred per cent., while only eight show increases of more than one hundred per cent. Within the area (west of Pennsylvania, north of the Mason and Dixon Line and west of the Mississippi), of the 27 states, seven report increases of more than two hundred per cent., while 19 of the 27 report gains of more than 100 per cent.

There is, to be sure, a partial explanation of these immense western increases in the increase in acreage. The number of acres devoted to farming purposes is greater in 1910 than in 1900. This increase is not, however, considerable. Although the population west of the Mississippi increased 30 per cent. between 1900 and 1910, the total number of farms increased only 18 per cent., the total acreage in farms increased only 9 per cent., and the total amount of improved land in farms increased only 29 per cent. If the reader will bear in mind the fact that the northeastern section of the United States is increasingly dependent upon the West for its food supply, the increase in the amount of farm land west of the Mississippi is less than might have been expected.

An appeal to the census table showing the value of farm land per acre bears out the suggestion that the increase in western farm land values can not be attributed to increased acreage. The percentage of increase in the value per acre of all farm land between 1900 and 1910 was 108 per cent. In the New England, Middle Atlantic, East North Central and East South Central States, this increase in value per acre was less than one hundred per cent. For the other groups of states, namely, for those lying west of the Mississippi, the increases ranged from 146 per cent. for the Pacific States to 222 per cent. for the Mountain States. An examination of the figures for individual states shows that among the 14 New England, Middle Atlantic and East North Central States (lying east of the Mississippi and north of the Mason and Dixon Line), only one state (Illinois, 105 per cent.) shows an increase of over one hundred per cent. Among the 22 West North Central, West South Central, Mountain, and Pacific States, only two states, Minnesota (73 per cent.) and Louisiana (85 per cent.), show increases of less than one hundred per cent. in farm values per acre; while nine states show increases in the value per acre of between two hundred and three hundred per cent., and one state (Arizona) shows an increase of 476 per cent. Among the eastern states the increases in farm land value per acre are therefore comparatively small—less than one hundred per cent. in all but two instances. Among the states west of the Mississippi, on the other hand, the increase in value per acre has been immense—more than

one hundred per cent. in twenty out of twenty-two cases, more than one hundred and fifty per cent. in fifteen out of twenty-two cases, and more than two hundred per cent., in ten out of twenty-two cases.

The total figures showed that the bulk of the increase in the farm land values in the United States between 1900 and 1910 occurred west of the Mississippi. The figures for increases per acre lead inevitably to the same conclusion, namely, that the farm land in the states lying west of the Mississippi has increased, during the past decade, between one hundred and three hundred per cent. in value.

The same movement for the increase in farm land values has apparently been going on steadily for sixty years. Although the census figures prior to 1900 gave the value of land and buildings together, the value of farm land predominates to such an extent that the figures for land and buildings are indicative, though not conclusive, for the increase in the value of the land.[8]

The acreage increases between 1850 and 1910 were so extensive in the states west of the Mississippi that it would scarcely be fair to cite increases in total farm land values. It is interesting, however, to note that during these six decades the total number of farms in the entire United States increased from one and a half to six millions; that the total land in farms increased from 294 millions of acres to 879 millions of acres; and that the total improved land in farms increased from 113 millions of acres to 478 millions of acres. Thus the total number of farms increased fourfold, the total acreage in farms threefold and the total improved land in farms fourfold, while the total population increased slightly less than fourfold. Meantime, the total value of all farm property rose from 3,967 million dollars to 40,991 million dollars (an increase of tenfold); and the value of farm land and buildings rose from 3,272 million to 34,801 million dollars (an increase of elevenfold).

The increase in the value of farm land and buildings between 1850 and 1910 is distributed very irregularly over the different sections of the country. For the entire United States the increase in the value per acre was from $11 to $40; in New England the increase was from $20 to $36; in the Middle Atlantic States, from $29 to $57; in the East North Central States, from $13 to $75; in the South Atlantic States, from $6 to $23; and in the East South Central States, from $6 to $21. West of the Mississippi the increases in value per acre were, for the West North Central States, from $6 to $50; for the West South Central States, from $6 to $19; for the Mountain States, from $6 to $21; and for the Pacific States, from $1.55 to $48. A comparison over so long a

[8] In 1910 the total value of the farm land alone was 28 billion dollars; of the farm buildings the value was 6 billions, or about a sixth of the total value of farms and buildings combined. The proportion was approximately the same in 1900—land value, 13 billions; buildings, 3½ billions.

period is really unfair, because up to 1890 the agricultural land of the Far West was a negligible quantity in so far as its value was concerned. These figures do show, however, the immense increase which has occurred.

The really important material on the increase in farm values is available only between 1900 and 1910. The other data are, however, of considerable significance. The whole body of information indicates that in those sections of the United States from which the food products of the country are chiefly derived, the land values during the last few decades have increased at a very rapid pace, culminating in the decade between 1900 and 1910 with an increase for ten years of double, treble or quadruple their 1900 values.

For manifest reasons, the increases in the values of lumber lands were prodigious, yet in many instances they are insignificant when compared with the increases in agricultural land values, which should yield an essentially stable value over so short a period as ten years. Instead agricultural land has fairly leaped into the field of rising values.

While farm values constitute the chief concern of the territory west of the Mississippi, the northeastern section of the United States is interested primarily in city land values. Did the census officials devote even a tithe of the effort to the determination of city land values that were lavished upon farm values, there would be collected a body of data valuable in the extreme. No such procedure has been adopted, however, hence the unfortunate seeker after the truth of changes in city land values is compelled to rely on the little information that may be culled from private sources.

Most American cities have no record at all of the increase in the value of land separate from improvements. Indeed, a prominent land-valuation expert goes so far as to write:

> I do not believe that any authentic information concerning the increase of city land value exists. Until assessments are made by the same method everywhere, there will be little in the way of statistics that will exhibit the information you desire.[9]

In one sense this statement is perfectly correct. The data which have been collected on land values are neither authentic nor scientific. They are, however, indicative of a certain tendency which Mr. Richard M. Hurd, president of the Lawyers' Mortgage Company, characterizes by saying,

> In general land values have increased enormously in the best part of the leading American cities; the land is now selling, in many sections, from two to three times the figures given in my book.[10] (Published in 1903.)

[9] A personal letter, December 23, 1912, from E. W. Doty.

[10] A personal letter, December 24, 1912.

Innumerable instances might be cited to support the contention that city land values have risen. For example, the New York City Commission on Congestion of Population cites the increase in the cost of lands purchased for school purposes. On the Island of Manhattan, the land in connection with School No. 14, at No. 33 Greenwich Avenue, cost, in 1849, 79 cents per square foot; in 1851, 84 cents per square foot; in 1890, $8.40 per square foot.; in 1897, $9.56 per square foot; and in 1905, $12.37 per square foot. In the Bronx, School No. 18, on Cortland Avenue between College Avenue and 148th Street, secured land in 1848 for 3 cents per square foot; in 1885 for $1.07 per square foot; and in 1896, for $2.18 per square foot. School No. 34, in Brooklyn, at Norman, Eckford and Oakland Streets, purchased land in 1867 for 23 cents per square foot; in 1904, for $3.16 per square foot; and in 1906, for $7.16 per square foot.[11]

A very effective study was made by the New York City Club (Homer Folks, chairman of the transit committee) regarding the increase in land values resulting from the construction of the rapid transit lines. Along the route of the new subway, assessment values, as given by the Department of Taxes and Assessments, were taken for the year 1900 on vacant lots. These were compared with the assessment values of 1907, the figures in each case representing one hundred per cent. valuation.

To ascertain the proportion of the increase in land value attributable to the building of the subway, it was necessary to deduct from the total rise what might be termed a normal rise, or the increase that would have taken place through the natural growth of the city, without added stimulus of a new transit line.

This normal rise was determined by taking the increase from 1893 to 1900 on the same territory. The study shows that up to 110th Street the increase in land values between 1900 and 1907 was about forty-five per cent. This equaled the normal rise previously determined. The Subway apparently made no difference in this land, because excellent elevated connections already existed. Between 110th Street and 129th Street the increase "was much more noticeable, averaging about seventy per cent." The location of Columbia University at this point rendered the calculations of little value. From 135th street northward the problem appears stripped of complications. "The aggregated rise in this land from 135th Street to Spuyten Duyvil was about $69,300,000." The estimated normal rise of $20,100,000 was therefore exceeded by $49,200,000 "apparently due to the building of the subway." This increase is one hundred and four per cent. increase on the value of 1900. A similar rise in the land values of the Bronx was shown. Between the

[11] Report of the New York City Commission on Congestion of Population, February 28, 1911. New York, Lecouver Press Company, pp. 56–57.

Harlem River and Bronx Park the increase in land values due to the building of the subway was $31,300,000.

The report goes on to state that, while the increase in land values above 135th Street, due to the building of the subway, was $39,200,000, the cost of building the subway from this point to 230th Street was $7,375,000, or but 15 per cent of the actual rise caused by the new line. Similarly, the increase in the Bronx land values of more than thirty million dollars was caused by subway construction costing $5,700,000.[12]

These instances are typical of the land value increases which are so apparent in New York City. Other great centers of population, however, show similar conditions. Mr. C. B. Fillebrown, in his "The A-B-C of Taxation," cites some interesting illustrations of increases in the land value of Boston. For example, the land values irrespective of improvements,

> on both sides of Winter Street, including the estates on the Tremont and Washington Street corners were in 1898, $61.57 per square foot; in 1907, $97.50 per square foot.[13] . . . The land in Winter Street, which was assessed at less than four dollars per square foot, in 1850, was assessed in 1907 at one hundred and thirty dollars per square foot. During the fifty-seven years intervening, the income, above taxes, from the land, in rent and appreciation has amounted to an average of one hundred and fifty per cent. annually on the investment of 1850.[14]

Similar illustrations might be cited in endless detail, showing the rise of land values in American cities. Even the casual observer must admit the very obvious facts of land value increase. The one thing needful is some accurate measure of their extent.

There are a few American cities in which a careful assessment of land independent of improvements has been made. In New York City, for example, the land and improvements have been separately assessed since 1906. The Report of the Commissioners of Taxes and Assessments for 1912 (pages 20–23) gives the land value assessments in considerable detail. The value of the land alone for Greater New York was, in 1906, 3,367 million dollars, and in 1912, 4,563 million dollars. This represents an increase in the per capita value of land from $811 in 1906 to $898 in 1912. Incidentally, the total value of all improvements in 1912 was only two billion, seven hundred and sixteen millions, or about three fifths of the total land value.

The boroughs separately show a considerable divergence in the ratio of increase. In the Borough of Manhattan, for example, the increase in

[12] "Building of Rapid Transit Lines in New York City." A memorandum addressed to the Board of Estimate and Appropriation by the City Club of New York, October 2, 1908.

[13] C. B. Fillebrown, "The A-B-C of Taxation," New York, Doubleday, Page and Company, 1912, p. 56.

[14] *Ibid.*

the value of the land between 1906 and 1912 was from $1,196 per capita to $1,296 per capita. This represents a total increase in land value of more than five hundred million dollars. In the Borough of Bronx the per capita land value fell from $771 to $657. This decrease was due primarily to the fact that during these six years the population of Bronx was almost doubled. For this borough, the total land value increased sixty per cent. For the Borough of Brooklyn, the per capita valuation rose from $325 to $450. The population increased less than twenty per cent. and the land value rose from 456 millions to 786 millions. The Borough of Queens, which is the least developed in Greater New York, shows an increase in per capita land value from $388 to $862, an increased 60 per cent. in population and an increase in the total land value from 81 millions to 278 millions. The problem in the Borough of Richmond is very similar to that in Brooklyn.

Although the land valuations in New York extend over only six years, they show that during that time the total increase in the value of the city's land was about 40 per cent., while in the newer sections of the city, notably in the Bronx and in Queens Borough, the increase was about 60 per cent. Neither in their totals nor in their proportions do these increases compare with the increases in timber land values or in farm land values. If the increase in New York land values is compared with the increase in the farm land values of the richest agricultural states, or of the best timber lands, they are comparatively small.

The land of Boston has been assessed separately for the improvements, at "the full and fair cash valuation" since 1887. There has been no material addition to the area of the city of Boston during this time; in fact, the number of square feet of land taxed decreased from eight hundred and ninety-six million in 1876 to eight hundred and fifteen million in 1912. This decrease was due to the taking of land for streets and other public purposes. It is interesting to note in this connection that between 1896 and 1911 two of the twenty-five wards in Boston show a decrease in land value; one shows an increase of one hundred dollars; one shows an increase of twelve thousand dollars; while twenty show increases varying from one million to twenty millions of dollars.[15]

The value of all land in Boston between 1887 and 1911 has increased steadily.[16] There is no year during the period that shows a decrease. In 1887, the land valuation was 322 millions. For the next two decades it was:

1890	$365,548,000	1905	$618,642,000
1895	443,695,000	1910	672,100,000
1900	532,934,000	1911	685,484,000

[15] Annual Report of the Assessing Department for the Year 1911, City of Boston Printing Department, 1912, p. 46.

[16] *Supra*, p. 16.

Twenty-four years show a total increase of slightly more than 100 per cent.

The land values of Boston are therefore increasing at less than half the rate of those of New York. During the years for which comparison may be made (1906–1911) the land values of New York rose 38 per cent., while those of Boston rose less than 8 per cent.

Two other cities in the East make separate assessments of land and improvements. The increase for these cities is:

Trenton, N. J.[17]		*Newark, N. J.*[18]	
1906	$21,866,000	1907	$122,904,000
1907	21,707,000	1908	121,465,000
1908	21,735,000	1909	125,515,000
1909	21,866,000	1910	129,469,000
1910	22,140,000	1911	134,764,000
1911	23,530,000	1912	141,059,000
1912	23,561,000		

Although the period covered in both cases is short, the rate of increase is very similar to that of Boston for a similar period. The seven years in Trenton show an increase of slightly less than one tenth and in Newark of one seventh.

The records of some western cities furnish a striking contrast in this ratio of land value increase. Milwaukee in the Middle West assessed land in 1890 at $52,386,000. For succeeding years the assessment was:[19]

1895	$74,229,000	1905	$85,961,000
1900	75,816,000	1910	99,502,000

For 1911 and 1912, the basis of assessment was increased from 60 per cent. to 100 per cent. The 1912 valuation was $193,799,000. The rate of increase for Milwaukee is somewhat greater than for Boston, though not so great as for New York. (Between 1891 and 1912, the area of Milwaukee was increased from 21 to 24 square miles.)

The three far western cities for which separate land assessments were secured[20] (Dallas and Houston, Texas, and Seattle) report far more rapid rates of increase.

[17] Letter from Commissioners of Assessment of Taxes, December 18, 1912.

[18] Letter from the Board of Assessment and Revision of Taxes, December 27, 1912.

[19] Letter from the Deputy Tax Commissioner, December 31, 1912.

[20] The facts for San Francisco are likewise available, but are rendered very inconclusive because of the fire. The land assessments then were:

1905–06	$304,135,000	1910–11	$288,095,000
1906–07	237,038,000	1912–13	301,196,000
1908–09	258,652,000		

(Annual Financial Statement of San Francisco, 1911–12, p. 156.)

City of Dallas[21]		*City of Houston*[22]		*Seattle*[23]	
1907	$16,477,000	1904	$19,787,000	1905	$ 70,038,000
1908	21,300,000	1905	20,588,000	1906	125,735,000
1909	21,356,000	1906	23,682,000	1907	155,751,000
1910	38,530,000	1907	30,353,000	1908	178,427,000
1911	44,468,000	1908	30,486,000	1909	184,737,000
1912	44,605,000	1909	36,533,000	1910	205,309,000
		1910	36,627,000	1911	212,014,000
		1911	46,916,000	1912	212,929,000
		1912	61,389,000		

There has been no considerable increase in the acreage of Dallas or Houston during the period under consideration. The acreage of Seattle, however, has increased from 29 to 60 thousand acres, between 1905 and 1912. The table is therefore worthless for comparison.

Many Canadian cities make separate assessments of land and improvements. Though they are outside the strictest limits of the discussion, they are probably typical of the rapidly growing towns in the western states. It is at least worth noting that the land values in Vancouver more than trebled between 1895 and 1909, that the increase in Victoria is approximately the same, while in the newer cities like Winnipeg the increase in valuation is even more rapid.

City land values are increasing—slowly in the east, more rapidly in the west. Each decade sees from twenty per cent. to one or two hundred per cent. added to the value. Still the rate of increase does not compare with that for forest or agricultural lands.

The increase in the land values throughout the entire United States has been immense during recent years. Particularly since 1896, timber and farm land values have advanced rapidly in price. City land values, though less rapidly, have risen none the less surely. What the future may hold in store for a nation whose timber lands treble, and whose farm lands double, in value during a single decade, the student of statistics may not venture to prophesy. The matter is at least worthy of serious consideration.

[21] Letter from the Commissioner of Finance and Revenue, April 8, 1913.

[22] Letter from the chairman of the Board of Appraisement, December 20, 1912.

[23] Letter from the County Treasurer, April 1, 1913.

THE SCIENTIFIC STUDY OF CHILD DEVELOPMENT

By JAMES BURT MINER, Ph.D.

ASSISTANT PROFESSOR OF PSYCHOLOGY, THE UNIVERSITY OF MINNESOTA

THE public recognition that questions of development are different from questions of health has caused a constantly increasing demand for another type of expert than the physician. We may call him an expert in child development. When a parent stops to consider the matter he knows that neither the short boy nor the short-minded boy is primarily a sick boy. Moreover, if a child is persistently poor in mathematics, it is not because of ill health. Mathematics makes him sick, but in a different sense. He may lack the native interest necessary for a mental flight into the fourth dimension. When a mother discovers that her daughter can not play the piano, she does not take her to a doctor. She recognizes that it is a question of the absence of a capacity for music or of improper training. Which fault it is, she often can not tell.

The expert in judging development must understand, not only how the child is influenced by disease, but also how it is influenced in other and more fundamental ways by hereditary tendencies, environment and education. The attempt to specifically prepare such experts began some fifteen years ago with the establishment of the first psychological clinic. This work has now been taken up by half a dozen of the leading universities. Graduates, trained by their psychologists, are giving special service of this character in connection with the public schools, juvenile courts, bureaus for vocational guidance, special schools for exceptional children, schools for feebleminded, correctional and penal institutions. Besides improving the methods for diagnosing the individual child, scientific study is now rapidly increasing the data for deciding how large groups of children should be handled in school and out. This study of groups has been called to general attention most prominently by various investigations of laggards in the public schools. The most extensive of these is an elaborate report by Professor George D. Strayer, published by the U. S. Bureau of Education, which covers hundreds of cities scattered throughout the country. To understand what the scientific study of development stands for, it is necessary to consider both the researches which are directed at the study of groups of children and those which emphasize the prolonged study of particular children.

Practical people and school authorities everywhere are forcibly aroused when they learn, through the statistical studies, that our public educational system is based upon a theory of the pupil's progress in school which perhaps miscalculates by two years the success of the ordinary child in passing through the grades. According to the estimate of retardation made by Ayres, the average child in the country at large would not complete the eight grades in less than ten years. This means unmistakably that a decided change must be made either in the curriculum or the teaching if our schools are to become adapted to the abilities and needs of the average child.

Group studies are being made of many other sides of child life. A recreation survey of the city of Milwaukee, made by Mr. Rowland Haynes, a field secretary of the American Playground and Recreation Association, brings out, as do similar surveys elsewhere, many facts which bear upon the most dangerous part of the child's day, the play hours. With about 350,000 tickets sold weekly on the average to shows in Milwaukee, 60 per cent. are to moving picture shows and 21 per cent. to vaudeville houses. The public has not begun to realize the tremendous possibilities of the moving picture show for good and bad. Again, this report shows that, after allowing 300 children to play on every usable acre of public and private play space within three districts tested, half of the thousand children enumerated would have to play in streets or alleys or not play at all out of doors in those districts. Perhaps even more significant of a condition of child development is that for 1,400 children observed in these districts outside of school hours, half of them were neither working nor playing, but doing nothing. Idleness, mischief and bad development probably correlate closely in the child's make-up.

For those who can stand statistics or, perhaps I should say, understand them, the frequent enumerations of child welfare conditions have served to demonstrate the needs and dangers of childhood. We have learned of the tremendous unnecessary waste of life through infant mortality, which is the most important health problem of the day, because proper care will here save the most lives. Statistics have also shown the need for medical and dental treatment for school children. Lying back of these problems are still more fundamental biological problems of eugenics and euthenics. A whole school of statistical experts traces its origin and inspiration to the personality and work of the late Francis Galton, who established just before his death the Galton Laboratory of Eugenics in London. The work of these eugenic experts and the biometrists is making it clearer every day that the problem of the mental defective is mainly a problem of heredity.

There is a childish query which aptly puts the question of inheritance and environment. A little lad was gazing raptly at the stove

when he suddenly burst forth with one of those inspirations of infants: "Oh, papa, suppose our cat had kittens in the oven, would they be kittens or biscuits?" Many biometrists would agree with papa that the oven is not so important as the old cat. The more this group of scientists studies mental defectives and bad boys the more evidence they disclose that to get good biscuits you must have good dough, that the dough out of which boys are made is more important than the "dough" spent in bringing them up.

Statistical inquiries will lay bare the great underlying causes at work in modifying human development. They are essential to estimating the relative importance of public questions which the community must settle, and they enable society to attack intelligently its most vital problems. On the other hand, when we come face to face with the question what shall we do with a particular child, statistics are often woefully dumb. We may know that a town is seriously affected by its unrestrained temptations to strong drink, and yet the particular boy we are interested in may not be at all influenced by this temptation. We may know that a hundred women successively admitted to the reformatory at Elmira, N. Y., were all feebleminded, as was recently discovered, and yet this does not settle the question whether or not the girl we have before us is weakminded. The statistical cross-section studies of groups must be supplemented by prolonged studies of the same individuals before we shall be able to scientifically apply our knowledge to particular cases.

It is because the now well-known method of measurement devised by Professors Binet and Simon, of Paris, is of importance in diagnosing the mental development of a particular child that it has given so much impetus to the study of childhood. When one reads the literature on the subject it is easy to get the impression that the diagnosis of mental age begins and ends with the Binet tests. This is one of those popular mistakes which is very disquieting to the scientists. Ever since the first psychological laboratory was established in Leipzig in 1879, a large part of the work in this science has borne directly or indirectly upon the problem of mental measurement. The attempt of an inexperienced person to measure intelligence or to use the Binet scale without some knowledge of this twenty years of investigation along similar lines is likely to be more or less of a farce. Even the studies that have been made the past five years of the Binet tests alone would fill a good-sized volume. There are at least half a dozen materially different English translations and adaptations of these tests. In this situation a parent had better trust the opinion of the school teacher as to his child's mental development, than to depend upon a diagnosis by the Binet scale which is made by a person inexperienced in psychology and in the use of laboratory tests. A properly trained expert, however, can diagnose

a child's mental age within a year, and thus provide an important check upon the opinion of his school teacher.

Perhaps I can illustrate the reliability and value of these mental examinations of children by telling a joke on myself. In a paper read at the State Conference of Charities and Correction, I cited an example of the examination by a student of mine of twenty boys at the Minneapolis Juvenile Detention Home. I stated that among these twenty there was only one boy who was normal mentally and in the proper grade at school for his mental development. Later, in going over these examinations again, I noted a fact, which had escaped me before, that among these twenty boys reported was the son of the superintendent of the home. What was my surprise to find that it was he who was normal and in his proper school grade. The examinations had indirectly singled out the only boy on the farm who was not a juvenile delinquent, as well as brought out the irregular mental and scholastic development of delinquents.

The most important part of a diagnosis of development is, of course, not the question what stage has this child reached now; but what accounts for his retardation, if he is retarded, and what improvement may we expect in the future if his physical or environmental handicaps are corrected and he is given proper training from this time forth. So far as this prognosis is concerned its value to-day depends largely upon the experience and judgment of the person making the prediction. We are only beginning to gather and record these data for prognosis and it will be years before we can make predictions with the scientific precision that is to be desired. A beginning, however, has been made. We know that if a child stands still in his mental development for a year after receiving the best medical treatment and under expert training then we may be reasonably sure that all except the simplest school training is virtually wasted. We should have a case of arrested development resembling the case of Abbie described by Dr. Goddard. Abbie came to the New Jersey Training School when she was eleven years old with a mental development that was about that of a seven-year-old child, as nearly as can now be judged. After receiving expert training and treatment for ten years she was examined and found still to have a seven-year-old mind. The ten years thrown away in trying to teach Abbie to read and cipher might have been much better spent in improving her work in those employments suitable for a seven-year-old child, and then allowing her to occupy herself with them under proper guidance. If the seriously deficient child is to be permanently isolated from society, as has been suggested by experts in eugenics, the public would undoubtedly be better satisfied to have the final disposition of these cases postponed until after a year or more of special training following the diagnosis. This suggestion has been made by Dr. H. D.

Newkirk, director of the juvenile-court clinic in Minneapolis, and it merits careful consideration by those formulating our laws.

In rare cases, on the other hand, we find that the mentality is in advance of the child's school attainment. I have in mind one boy whom we examined in our clinic who was brought to us by one of the probation officers from the juvenile court. He had attended one school after another, jumping about from parochial to public school and back again with no assistance at his home and general neglect on the part of his incapable parents. We found him to be nine years old intellectually and yet he was not succeeding in first grade work. He was thus retarded at least two years in school attainment. In thirty hours of expert training, after he had been properly fitted with glasses, he was taught to read in the Second Reader, although he could not read in the First Reader when the training began. A decided deficiency in mathematics or reading has thus been overcome occasionally by special training.

In one system of schools in the east, examined by Dr. H. H. Goddard, about one out of five pupils who were retarded in school attainment were shown by mental examinations to be at least a grade behind the grades most frequently reached by pupils of their mental development. Some of these were undoubtedly kept back because they had started school after they were seven years of age or had been long absent. We should hardly expect a fifth of the scholastic retardation to be corrected by brief expert training, and yet how much might thus be alleviated we do not know. It is one of the most important questions that has been raised by these tests for ability.

The measurement of the intellect, such as is accomplished by the Binet scale, should not be overemphasized. It is only one of the ways in which the study of individuals has of late been undertaken. The Vocational Bureau at Boston and vocational tests in Cincinnati have opened a large field. The child welfare work makes another demand. In mentioning the recent impulses to child study, which seem to be thrilling the social body, we should not slight what promises to give the greatest inspiration to this movement, I mean the work of Maria Montessori. Dr. Montessori has rediscovered the golden rule of scientific education, observe how the child develops. Instead of inviting a healthy young fledgling to ride in his teacher's air-ship, she would let him try his own wings under guidance of a mother bird.

The moral development of the child has been most recently brought under scientific observation in connection with the clinics established at several of the juvenile courts. Dr. William Healy organized the first of these about four years ago in Chicago. Several such clinics are now accumulating most interesting data. We have found in Minneapolis, through a survey of about 300 boys and 100 girls consecutively

found delinquent in our juvenile court, that the most prominent measurable difference between these delinquents and the ordinary school children is apparently their retardation in school and in mental development. Seven out of ten of the offenders among the boys and nine out of ten among the girls were lagging a year or more behind the average position attained by those of their ages in school. This frequency of retardation in the delinquent groups is three and four times as great as among Minneapolis school children generally. When the average amount of retardation in school is considered it is found to be nine times as great among the delinquent boys and twenty times as great among the girls as among school boys and girls generally in the city. In intellectual development the indication is that over half of the repeaters and those sent to the detention home or state training schools are a year or more backward, while about twenty per cent. are three years or more retarded mentally.

Another serious condition which our study has disclosed is that nearly half of the girls who get into the juvenile court and half of the boys at the detention home are living with one parent or with neither. In other words, half of these more serious offenders and half of the delinquent girls come from homes which have been broken up by death, desertion or divorce.

Any child will be handicapped by disease, physical defects, bad training, or unsympathetic and improper environment at home, in school or at play. The removal of these handicaps, however, does not at once convert a youthful offender into an intelligent and upright citizen, when he has been subject for years to these baneful influences. This is a lesson which the difficulty of reforming character always drives home. To make a good boy or girl requires more than restoring his health and giving him some money to spend. He must be taught how to use his strength and his resources. This is a vastly more difficult problem than curing a disease. How difficult this training problem is may be indicated by telling you the story of one of the boys we have studied in our juvenile court work.

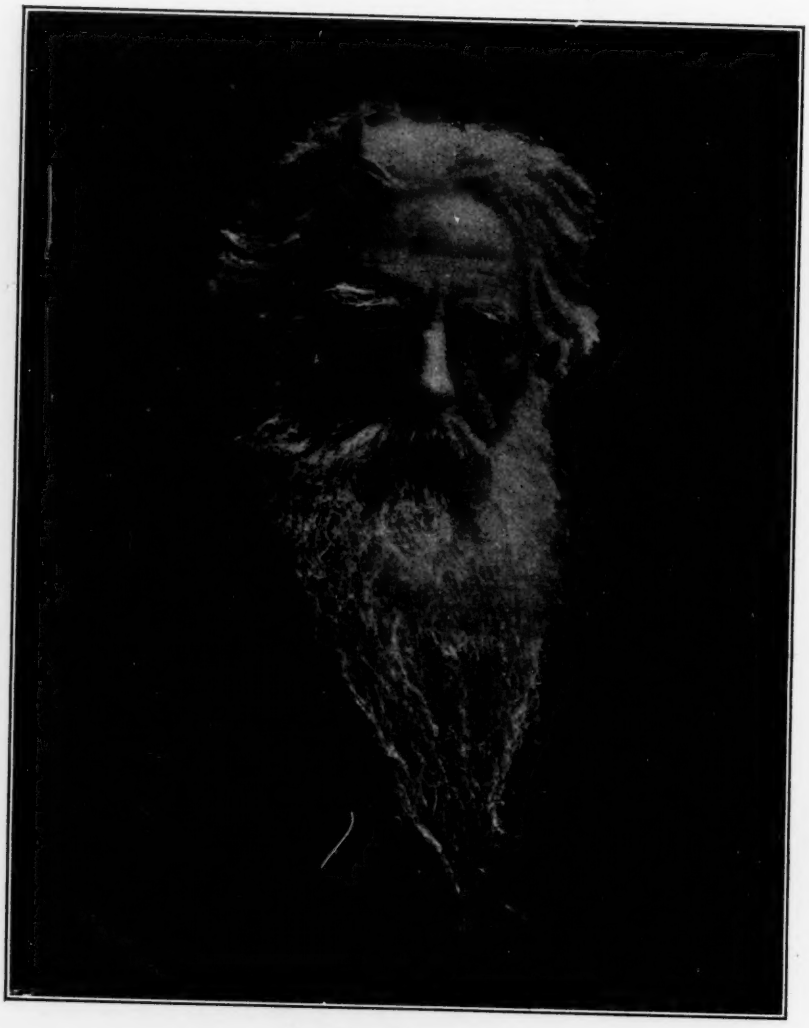
There is to-day nothing very bad about this boy, Harold, either as to his health or his mental ability, and yet his history shows a collection of physical handicaps which he carried from infancy. One of these disabilities of health made it impossible to send him to school until he was nine years of age. A year after that he had adenoids removed which had also been troubling him for years. Another ailment, with which he had suffered nobody knows how long and which would have kept him in a highly nervous state so long as it lasted, was discovered and corrected since the first of the year. Last December, when he was examined, he had the mentality of a child about two years younger than himself, although he had then been improving noticeably.

Since the removal of his last physical handicap I have examined him again and he is to-day about normal in his mental ability, having apparently advanced almost two years in type of intellectual activity in less than a year, largely because relieved of these physical drains on his vitality. The physical defects, we may say, are to-day practically corrected and he is quite a healthy boy. But the result of all these past handicaps has been serious for Harold and he has carried over to his present age of twelve years the childish propensities and childish lack of control which he acquired during those long years of childish mental existence, while he was associating with boys much younger than himself and amusing himself almost like a child in the kindergarten. One of these childish impulses, while it was little more than mischievous, has become so firmly established that society must be protected from the boy until he can learn to correct it and control himself. His particular passion is for horses. When the whim strikes him to take a ride, all of the restraints which his parents, his teachers, the probation officers, the court and a term at the detention home are able to pile up for him have apparently so little effect that he will not think twice before driving off the nearest and most convenient horse in his vicinity. Longer training at the detention home, which all desired, he has made impossible by running away almost as quickly as he is taken there, another manifestation of his childish lack of control. Five times he has come to his home in Minneapolis, 15 miles away, in spite of the warning that boys were sent to the State Training School for this. On the last of these visits at home he went to a neighbor's barn, harnessed up the horse and drove off with another boy for an evening's ride. After this lark they returned the animal unharmed to the stable. Having repeatedly tried and finally exhausted the entire list of milder forms of restraint, it was necessary for the good of the boy and the protection of delivery wagons to see what the more severe discipline of some months of life at the State Training School would do to break up this childish habit which has been carried over into youth, to teach the boy the self-control that must belong to young men and which he would probably have normally attained had he not been handicapped by the ill health which kept him for years in the stage of early childhood.

Harold was trained under favorable conditions at home and in school. There is an excellent prospect for him to turn out well; but how much more difficult is the problem when the home is a nest of filth and corruption, as it sometimes is. The probation officers have discovered homes of delinquents where literally the pigs are brought up in the parlor; others where children do not know what it is to sit down to a table for their meals, but walk about helping themselves to the family bowl of mush or loaf of bread. Worse than this are the examples of theft and vileness set by others in the house or neighbor-

hood. Fortunately, very bad conditions are rare; but they are frequent enough to make the need for assistance vastly greater than the supply.

With many of us who were born in the west the joy of pioneering still continues. In this work of training retarded children and youthful offenders we are again on the frontier, hewing down forests of bad habits and founding homes for the future generations. As our resources increase and our knowledge accumulates we may look forward to the time when we shall be able, at these border lands of society, to select the good seeds, mother them in a fruitful soil, weed out the tares, and raise a bumper crop of boys and girls that will do credit to the nation.



EADWEARD MUYBRIDGE.

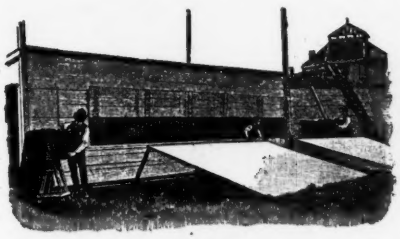
THE PROGRESS OF SCIENCE

THE SCIENTIFIC ORIGIN OF MOVING PICTURES

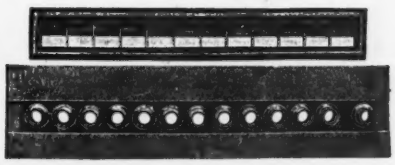
EADWEARD MUYBRIDGE began his experiments in instantaneous photography in California in 1872 and subsequently carried them forward at the University of Pennsylvania, which provided him with grants amounting to more than $40,000. We thus have an instance in which scientific investigation supported by a university has been the origin of an enterprise of immense practical and commercial importance. The annual receipts from moving-picture shows in the United States are about $150,000,000; a royalty of ten per cent. on these receipts would defray the entire cost of all the real university and research work in this country.

The experiments of Muybridge at the University of Pennsylvania were originally undertaken to study animal locomotion, and in this direction were of much importance, both for science and for art. Painters and sculptors should represent men and animals as they appear to the eye, not as they appear in instantaneous photographs; but the knowledge of the position of the body in movement, first learned through such pictures, is of value to the artist comparable with a knowledge of anatomy. Several of the original pictures taken by Muybridge are here reproduced from original plates in the possession of the University of Pennsylvania, by the courtesy of Mr. George Nitzsche, recorder of the university, who has contributed to *Old Penn* an article describing the methods used.

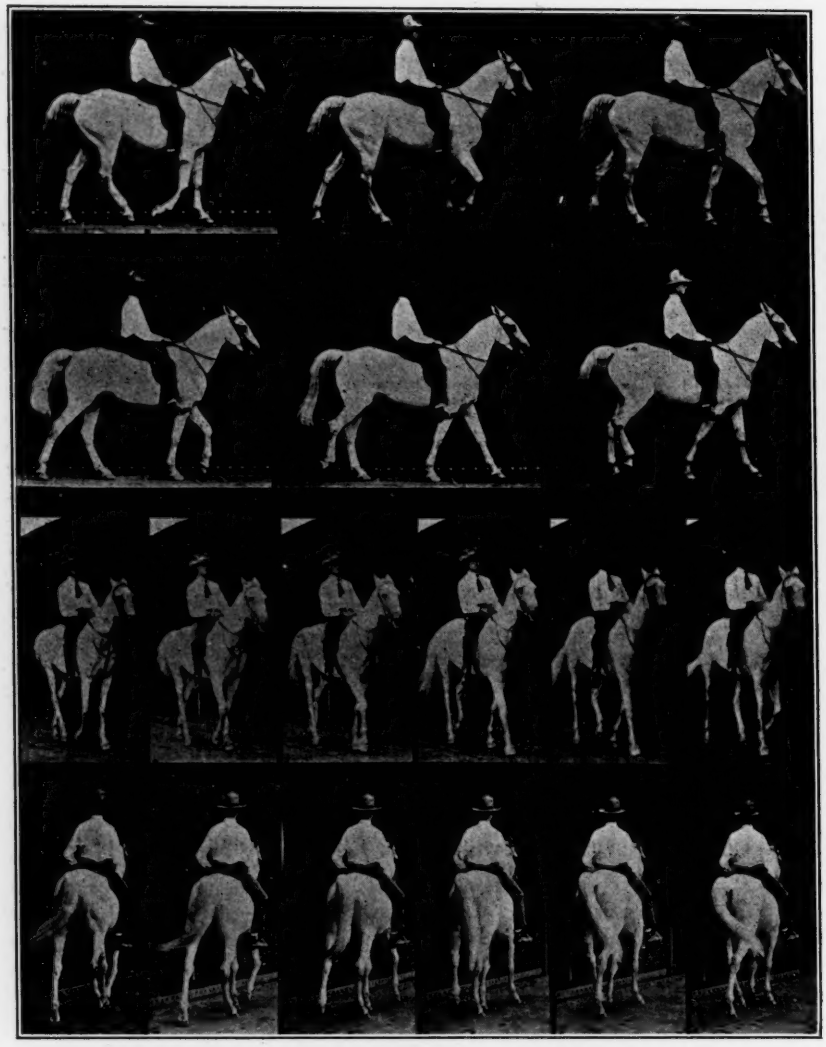
On the grounds of the University of Pennsylvania a shed was built, about 120 feet in length, painted black with a net-work of white threads. Opposite the shed was the camera-house, shown in the illustration, in which were 24 cameras, each having a lens 3-inches in diameter. The cameras were operated electrically by a motor clock, so that twelve successive exposures could be made in one fifth of a second. In some cases three batteries of cameras were arranged so that simultaneous views from different positions were obtained. Thus in one of the pictures here reproduced the stride of a walking horse is shown in 36 different photographs, twelve successive positions being reproduced from three points of view. There is similarly shown the front and side views of movements in making a high jump. Instantaneous pictures of animal locomotion were subsequently made by M. Marey in Paris, who used a sensitized film, so that a succession of pictures could be taken with a single lens. Mr. Edison later applied the film to the kinetoscope and to projecting moving pictures on a screen with a lantern.



BUILDING SHOWING BATTERY OF TWENTY-FOUR CAMERAS.



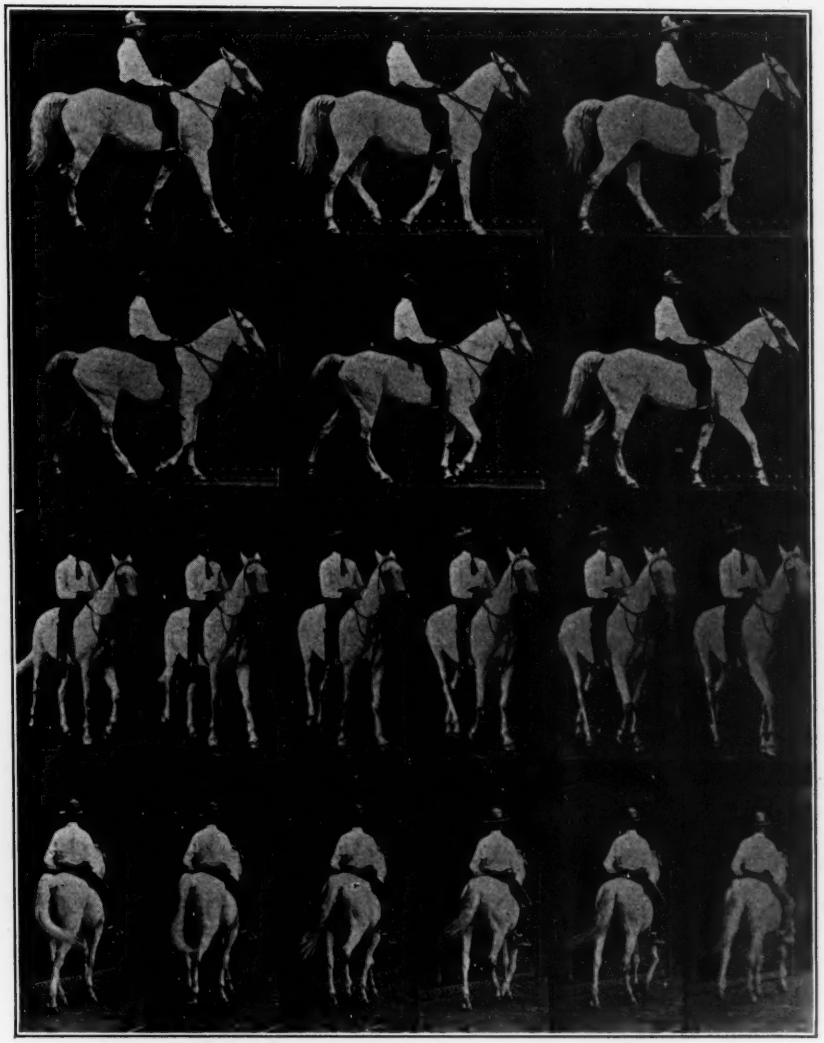
PHOTOGRAPHIC CAMERA DIVIDED INTO COMPARTMENTS, each having a lens of the same construction, and arranged to correspond with the compartments in the Electro Photographic Exposors.



WALKING HORSE. SIDE, FRONT AND

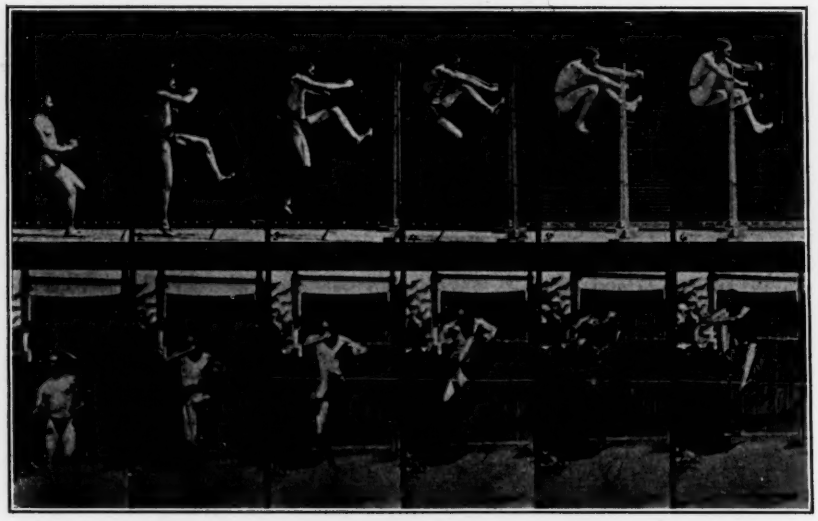
Muybridge, however, not only took the first photographs of moving objects but also first projected them on a screen, thus leading directly to the modern exhibitions of moving pictures. This he did in lectures, beginning in 1880, and on a large scale at the Chicago exposition of 1893, where a building was especially erected in which he exhibited flocks of birds flying across a screen, athletes wrestling and similar moving pictures. In 1886 Muybridge consulted the inventor of the phonograph with a view to reproducing simultaneously visible actions and auditory words. Neither method of reproduction was, however, at that time sufficiently advanced, and it was necessary to wait until last year, when Mr. Edison was able to synchronize in a satisfactory manner the pictures and the sounds.

Although the reproduction of a play by moving pictures and the phono-



BACK VIEWS IN TWELVE POSITIONS.

graph is far from being perfected, it may be that before long such copies of plays and operas by leading actors and singers with the best possible stage settings may be more effective than the average performance, as the photographic reproduction of a great painting may have more artistic value than an inferior original. As much as $150,000 has been spent on the production of a single set of films, and leading actors, such as Madame Bernhardt and Sir H. Beerbohn Tree have acted before the film camera. At present most of the shows exhibit crude farces and melodramas, and it may not be altogether satisfactory that a third as much money is spent on them as on our entire public school system. We may hope, however, that the moving-picture show will make possible a democratic development of art and become an educational institution of the greatest possible consequence.



ATHLETE MAKING STANDING HIGH JUMP.

LEGAL LIMITATIONS OF MARRIAGE

A PENNSYLVANIA law became operative in August, requiring those wishing to marry to appear at the license bureau and answer under oath some fifty questions. It is rather absurd to swear that one is not an imbecile, and a physician's certificate, as required by a law passed by the last Colorado legislature, is a better guard against communicable disease than a statement of the patient. Still such a law may be of use, though not so much in punishment following its violation as in the reflections and precautions which it may occasion in those who propose to marry. The laws of the different states limiting marriage relations have recently been summarized in a bulletin prepared by Dr. Charles B. Davenport and issued by the Eugenics Record Office. They are more numerous and complicated than most people suppose.

Marriages of idiots and the insane are illegal in about half the states and these marriages are presumably invalid everywhere, as such persons can not make contracts. On similar grounds in three states a marriage is invalid when one of the parties is intoxicated. Only five states forbid the marriage of those suffering from venereal disease. It should surely be made as serious a crime to communicate diseases as to commit larceny or assault and battery, and public sentiment would probably uphold legislation to this effect. In only a few cases have laws been passed with direct reference to the eugenic aspect of the case. Connecticut and Kentucky forbid illicit union with imbeciles, the latter state under penalty of twenty years' imprisonment. In Delaware a child of a parent insane before it was born can not marry. In Utah, an epileptic woman may marry after the age of forty-five, but not before.

Laws limiting closeness of relationship in marriage are based on social rather than on biological considerations. Indeed we have no scientific knowledge that would enable us to prescribe limits of consanguinity within which marriage is undesirable from the point of view of heredity or eugenics. The marriage of first cousins is illegal in about half of the states, including Pennsylvania and Illinois, yet such marriages have been and are common in all classes of society. The most distinguished family known to the writer

FRONT AND SIDE VIEWS OF TWELVE POSITIONS.

are the seven children of Charles Darwin, who married his first cousin. The royal families of Europe are closely inbred, but form a superior group. A consideration of their heredity shows, as might have been anticipated, that both desirable and undesirable qualities are enhanced by the marriage of those related by blood.

The social reasons making it desirable to forbid the marriage of those who become related through marriage are not urgent; indeed they have practically disappeared since segregation of the sexes has been largely abandoned. The limitations do not exist in many of the states and in others are curiously inconsistent. Marriage with a deceased wife's sister is not prohibited, but in West Virginia a man may not marry his deceased wife's step-daughter and in Massachusetts he may not marry his deceased wife's grandmother.

The laws in regard to intermarriage of races differ greatly in different states, as does public sentiment. Just now southern newspapers are urging the dismissal of a university professor because in an article in this journal he spoke kindly of the mulattoes. In Maryland whites and negroes or mulattoes who intermarry "are deemed guilty of an infamous crime," and are subject to ten years' imprisonment, while a mile away such marriages are legal. Apparently a white person and a mulatto who marry in Pennsylvania can return to live in Maryland, but would be subject to five years' imprisonment if they went to Texas. In California and in several other states marriage of a Caucasian with a Mongolian is illegal, and several states have laws against marriage with a North American Indian.

The diversity of the laws of the different states, marriages that are legal and approved by public sentiment in one part of the country being crimes elsewhere, indicates that it may be less difficult to apply eugenics in practise than it is to determine which kind of eugenics it would be desirable to apply.

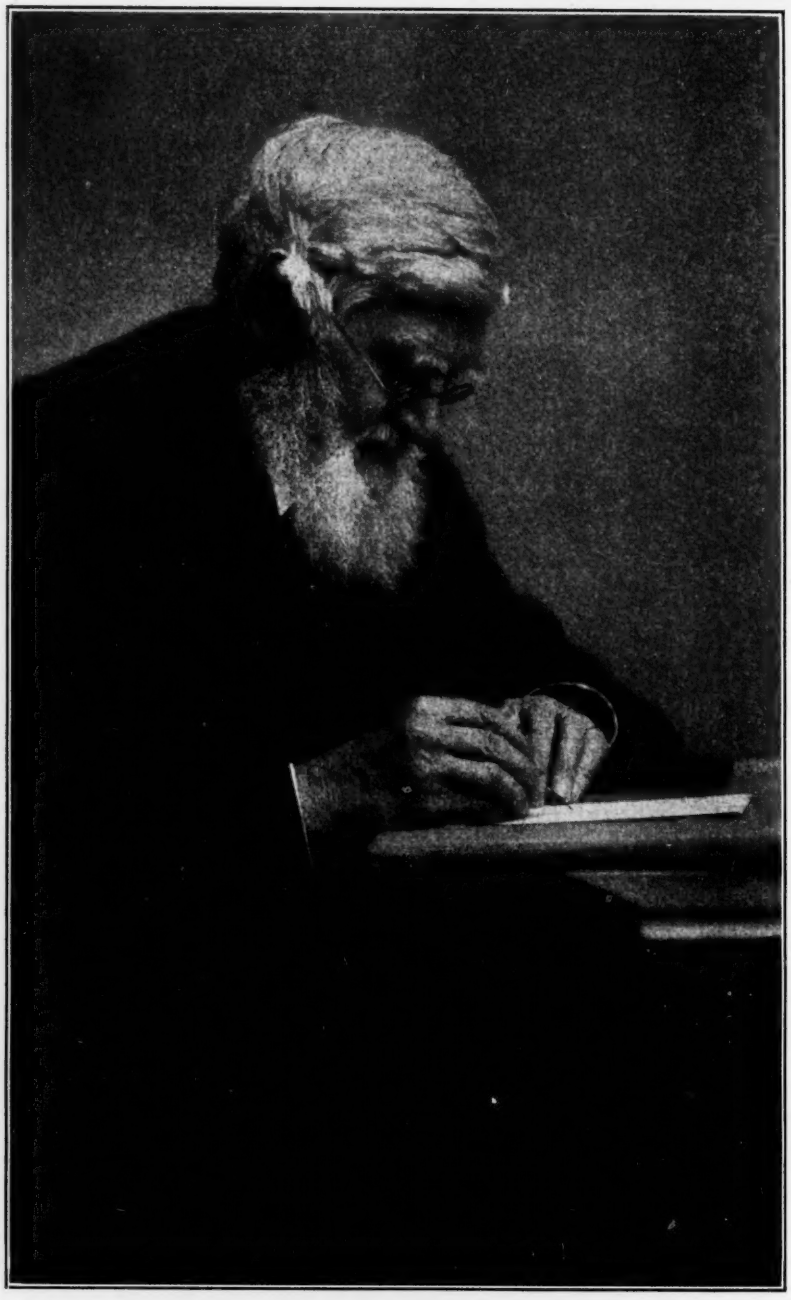
SCIENTIFIC ITEMS

WE record with regret the death of Dr. Reginald Faber Fitz, professor emeritus in the Harvard Medical School; of Dr. John Green Curtis, from 1876 to 1909 professor of physiology in Columbia University; of Professor Lucien Augustus Wait, emeritus professor of mathematics in Cornell Uni-

versity; of Dr. Alexander Macfarlane, of Chatham, Ontario, known for his contributions to vector analysis and quaternions; and of Dr. Charles Lester Leonard, professor of roentgenology in the University of Pennsylvania, who died from X-ray dermatitis, contracted in the course of his work nine years ago.

THE British Association for the Advancement of Science has accepted an invitation to hold the meeting of 1915 at Manchester. It will be remembered that next year's meeting will be held in Australia under the presidency of Dr. William Bateson.—The University of Birmingham on September 11 conferred its doctorate of laws on the following foreign representatives in attendance at the meeting of the British Association: Madame Curie (Sorbonne, Paris), Professor H. A. Lorentz (Leyden), Professor Keibel (Freiburg), Professor R. W. Wood (Johns Hopkins) and Professor Svante Arrhenius (Stockholm).—On the occasion of the meeting of the International Geological Congress at Toronto, the University of Toronto conferred the degree of doctor of laws on the following geologists: T. C. Chamberlin, U. S. A.; W. G. Miller, Canada; P. M. Termier, France; R. Beck, Germany; J. J. Sederholm, Finland; T. Tschermyschev, Russia, and A. Strahan, England.

THE government through Secretary of Commerce Redfield has decided to change the sale of all the government catch of seal, fox and other Alaska furs, from London to St. Louis. At the present time St. Louis is said to be the largest primary fur market in the world. It is estimated that three fourths of all the furs trapped on the North American Continent are shipped to St. Louis houses to be sold.



Alfred R. Wallace